THE ISLAND THAT BROKE THE OCEAN'S SURFACE AND WHAT IT LEFT BEHIND

Underwater cultural heritage management in Aruba

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Preface

The ocean has always fascinated me, in the sense that it has been here since the beginning of earth's formation. Therefore, the ocean and its affiliating water systems has an insurmountable amount of stories yet to tell about the history and evolution of mankind. Growing up on the beautiful island of Aruba, I was surrounded by the sea, and as I got older the more intrigued I became in what role this played in the history of Aruba. These interests steered me into pursuing a career in Archaeology. Archaeology is the study of buildings, graves, tools, artifacts, and other objects that belonged to people who lived in the past. Following the Cambridge dictionary, archaeology is the study of past cultures and societies (Cambridge Dictionary: https://dictionary.cambridge.org/dictionary/english/archaeology). During my bachelor's at Saxion University of Applied Sciences studying Archaeology, I was solely focused on terrestrial archaeology. However, I always had an interest in maritime and underwater archaeology, as trading, mobility, and war also occurred on the ocean. In addition, huge amounts of settlements and sites worldwide are now submerged due to the rising sea level. My first opportunity to delve into the world of maritime and underwater archaeology came with being able to choose an extra course in my current master's program at Leiden University. Of course, I jumped at the chance to follow the course "Advanced Underwater Archaeology and Maritime Landscapes", given by Martijn Manders. This is when I got into contact with professor Manders and was given the opportunity to pursue underwater archaeological research in Aruba. This is a very important opportunity for me as an Aruban to be able to make a contribution to archaeological work in Aruba, specifically in the maritime and underwater archaeological field. This thesis was therefore written as part of my master's program for the study program MA Applied Archaeology at Leiden University in Leiden.

Acknowledgements

I would like to thank Leiden University, the National Archaeological Museum Aruba, and my two mentors namely Raymundo Dijkhoff, Archaeologist and head of the Collections and Research Department at the National Archaeological Museum Aruba, and Martijn Manders, professor by Special Appointment in Underwater Archaeology and Maritime heritage management at the Faculty of Archaeology, Leiden University, and coordinator International Maritime heritage at Cultural Heritage Agency (RCE). Professor Manders provided guidance, feedback and advice in the study of managing the heritage in maritime and underwater archaeology. Within the National Archaeological Museum Aruba, Raymundo Dijkhoff, provided advice, guidance, feedback, and information regarding the history of Aruba, as well as Harold Kelly, Archaeologist, for providing advice and information of the history of Aruba and climate change. The above mentioned individuals made it possible for me to conduct this research and process the results for my graduation thesis.

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Chapter 1 Introduction

Underwater cultural heritage is portrayed within the environment as all material evidence of human activities carried out within a maritime and underwater environmental context (Da Silva and Villegas, 2021, p. 2). The material evidence frequently resides on the sea floor. The ocean's floor is littered with archaeological materials that are both known and unknown, accessible and inaccessible. However, advancements in maritime and underwater research improved the possibilities to preserve and protect the underwater resources present (known, unknown and future), and therefore manage underwater cultural heritage (Smith and Couper, 2003, p. 25). Due to the improvements within the research field, great strides can be made in regard to gathering knowledge of the underwater cultural heritage present in waters all over the world including the waters surrounding Aruba. The main focus of this research was to determine how to best preserve, protect, and manage Aruba's underwater cultural heritage.

1.1 Problem definition and relevance of the research

When looking at past maritime and underwater archaeological research in Aruba, no extensive research has been conducted on the archaeological underwater cultural heritage valued regions. The National Archaeological Museum Aruba (NAMA) is responsible for the recognition, documentation, and preservation of archaeological heritage. Extensive archaeological research has been conducted in Aruba since 1880 (Dijkhoff, 2004). However, Underwater- and Maritime Archaeology has only recently been incorporated within the Archaeology of Aruba. There was no management regarding Underwater- and Maritime Archaeology before the year 2000 (Dijkhoff and Linville, 2015). Locals were engaged in treasure hunting for their own private collections, to sell or to portray as landmarks in Aruba, there was no interest whatsoever in presenting or mentioning these finds to the museum or an archaeologist (Dijkhoff, 2011a, b). In addition, between 1980 and 2000, there was a goal to increase both tourism and coral reefs in the waters around Aruba, which led to the sinking of ships, boats, planes, and cars as diving sites (Dijkhoff, 2021; Dijkhoff, 2022; Dijkhoff, 2023).

The period between 1999 – 2008 consisted of the first scientific contact with underwater cultural heritage, which dealt with collaborative work, collecting scientific information, networking, and legislation matters (Dijkhoff, 2022).

The following years between 2009 – 2018 continued with collaborative work, networking and legislative matters, in addition to creating awareness to the importance of preserving and managing the underwater cultural heritage (Dijkhoff, 2022). The National Archaeological Museum Aruba incorporated a few selected underwater finds into the permanent exhibitions of the National Archaeological Museum Aruba (officially inaugurated in July 2009) in order to portray and inform locals and tourists that there are indeed underwater cultural heritage present in the surrounding waters and water systems of Aruba. In 2011, the NAMA participated in the UNESCO underwater cultural heritage convention that took place in Mexico and Jamaica followed by another in 2013 in St. Kitts. In addition, the year 2011 was important in creating an initial inventory of underwater cultural heritage of Aruba in order to explore the possibility to become protected monuments using the local Monumet Ordinance. This reason to try to use this legal regulation was because the Netherlands did not ratify the UNESCO 2001 Convention and consequently it could not be used to create local execution laws for the protection of Aruba's underwater cultural heritage. The process creating the initial inventory started due to the illegal extraction of a propellor belonging to the shipwreck SS Oranjestad in 2009 by the SS Oranjestad Memorial Committee (Dijkhoff, 2011a, b). The concept of a marine park was created in 2014. The first publishing regarding scientific data gathered from the underwater cultural heritage of Aruba was in 2012, and had the goal to spread awareness (Dijkhoff *et al*., 2012).

The National Archaeological Museum Aruba took spreading awareness a step further in 2017 by creating the "NAMA goes tech project" with Fundacion 1403, in order to attract the more digital generation. A formal petition of the autonomous Dutch Caribbean islands was approved in 2019 where they asked the Netherlands to officially ratify the UNESCO 2001 convention and which is planned to happen in the upcoming years. The UNESCO 2001 convention entails the protection of cultural heritage in the Dutch Caribbean (Dijkhoff, 2022). The first comprehensive desk-based research regarding Underwater Cultural Heritage sites in and around Aruba was conducted in 2021 by the National Archaeological Museum Aruba's head senior archaeologist Raymundo Dijkhoff (Dijkhoff, 2021). Thus, over the last 20 years Maritime- and Underwater Archaeology has grown in importance within the archaeological field of Aruba. This shift occurred due to a growing knowledge among researchers and the local communities, new development and techniques, and a rising participation of stakeholders.

Due to a lack of underwater archaeological research, the status of a large amount of underwater resources and cultural heritage present in the surrounding waters and water systems in Aruba are undetermined and/or unmanaged.

Creating an overview and gaining knowledge of the known and future underwater archaeological resources and what could still be present yet remain undiscovered (unknown/potential) are essential when it comes to land-use planning, sustainable exploitation of the landscape, infrastructure planning, tourism and recreation. This can therefore be compared to Aruba's official spatial development plans (Directie Infrastructuur en Planning: https://www.dip.aw/ropv/). Therefore, the following steps are needed to discover the resources and manage them, with the help of an underwater cultural heritage management plan, wherein understanding cultural heritage and cultural heritage management plays a key role.

When assessing the importance of the underwater cultural heritage for a population in relation to the known sites, how they are classified, why future heritage is important for the future generations, and the status of the underwater archaeological resources, an underwater cultural heritage management plan can be created as a starting point for future management and protection of the underwater cultural heritage sites. This thesis presents an analysis of the known, unknown, and future underwater archaeological resources, why it is important to manage the underwater sites based on the stakeholder's involved perspectives and the preservation status, and how to manage the underwater cultural heritage as a long-term plan.

1.2 Aims and approach

This thesis aims to be a useful long-term document, in addition to being the first step in creating an underwater archaeological cultural heritage management plan for the managers, policy makers and archaeologists who will use this as a guidance tool and background study for future management and evaluation of Aruba's underwater cultural heritage. What is important to note is that cultural heritage management is not solely focused on the archaeology present but works with the object and sites within a larger archaeological, theoretical, economical, and societal framework with each having different goals and methodologies. Therefore, this thesis will use the archaeological and historical data and database as a basis in combination with the different levels of importance of each stakeholder in regards to the underwater cultural heritage to create an overview on how to best manage the underwater archaeological resources that fall within the underwater cultural heritage of Aruba.

The important aspects such as the spatial distribution, amount of underwater cultural heritage present, the status of preservation, the natural and cultural threats that are currently affecting the resources, factors that the resources will be exposed to, the ways to manage it, and the effectiveness thereof will be explained within this thesis report in order to create an underwater cultural heritage management plan. The underwater archaeological resources and materials used for this thesis were gathered and are situated in locations spread out all over Aruba, and are distributed among three periods that span an indigenous to modern time frame, namely the Archaic (1500 BC – 900/1000 AD), Ceramic (900/1000 AD – 1515 AD), and the Indigenous Historic period (1515 – Present day).

1.3 Research questions

The following research question is central to this thesis report, which can be answered with the help of the sub-questions. The main research question and sub-questions were developed based on the points mentioned above.

The following main question was formulated for this thesis:
How can Aruba's archaeological underwater cultural heritage sites be managed?

The main research question will be answered with the help of the following sub-questions:

1. What is the level of significance of the archaeological underwater cultural heritage for the different stakeholders present in Aruba?
2. What are the archaeological underwater cultural heritage of Aruba?
3. What are the threat factors affecting the archaeological underwater cultural heritage of Aruba?
4. Why is it important to actively manage Aruba's archaeological underwater cultural heritage?

1.4 Methodology

When aiming to manage Aruba's underwater cultural heritage, the different underwater archaeological resources (known, unknown, and future), influencing threat factors, stakeholders, ethics, site accessibility, documentation, conflicts of interests, and the willingness to preserve the heritage were analyzed. This project was therefore divided into three phases:

1. Collecting data and creating a database with Aruba's known, unknown (potential) and future underwater archaeological resources and the significance thereof.

2. Create an overview of the threat factors affecting the underwater archaeological resources with accompanying maps portraying the locations and maps dividing the underwater and maritime landscape into a high, medium, and low zones for archaeological value based on the present day characteristics.
3. Create an underwater cultural heritage management plan for the underwater cultural heritage of Aruba.

The main methods used within this thesis report were a desk-based research, interviews, and a small material analysis. The first phase focused on the desk-based research and interviews. The desk-based research assembled information from both historical and archaeological sources available within the National Archaeological Museum Aruba and online sources. Therefore, a variety of maps were analyzed, namely historical and geological ones. This was done in order to gain insight into the former use of the landscape, in addition to hydrographic information. The information in turn was used to determine the known, unknown, and future underwater archaeological resources submerged along the entire coastline and inner waterways of Aruba (see figure 1). The known, unknown, and future underwater archaeological resources span from the precolonial period up until modern day. In order to gather insight into the significance of Aruba's underwater cultural heritage, interviews and analysis were conducted with the stakeholders (see chapter 2: Aruba's cultural heritage). Different interviews were conducted depending on the stakeholders. Structured interviews were conducted with fishermen, divers, and locals with the local interviews occurring via a forum. Unstructured interviews were conducted with the other stakeholders. This method was chosen as it makes it easy to introduce the theme and goal of the research, and therefore leaves the interview open for discussion on what the stakeholders hope to achieve with this research.

When the database was created of the known, unknown, and future underwater archaeological resources, the threat factors affecting the underwater archaeological resources were determined using scientific data to assess the marine environment, the chemical, biological, and mechanical deteriorations, (historical) photographs of the underwater archaeological resources, historical and topographical maps portraying the landscape characteristics, and the material analysis. Maps were created to portray the known, unknown, and future underwater archaeological resources within the marine environment.

The maps were created with QGIS through the analysis and interpretation of a range of geological and historical maps, in addition to analyzing a wide variety of historical photographs and data. Lastly, a small material analysis was conducted on one underwater collection within the National Archaeological Museum Aruba, namely 45 individually labeled finds lifted from the shipwreck SS Pedernales by Gino Wauben[1], and was donated to the museum in 2013. However, the date or dates in which the materials were lifted by Gino Wauben are unknown. The 45 individually labeled finds were analyzed and the following information were documented, namely the shipwreck site, location, region, type of material, sub-category material, object, and amount. The material analysis provided data in regard to the natural threat factors on the archaeological underwater resources, and are shown in attachment 2.

The goal of this research was to combine the knowledge and locations, when applicable, of the known, unknown, and future underwater archaeological resources, the significance it has to the local communities and the government, and what is causing damage to the underwater archaeological resources in order to create a long term underwater cultural heritage management plan to ensure that Aruba's underwater sites remained preserved for generations to come.

1.5 Thesis outline

This thesis is comprised of eight chapters, with this chapter being the introduction. The introduction is followed by chapter two explaining (underwater) cultural heritage and the significance it has on the different stakeholders involved in the management of the underwater cultural heritage. Chapter three gives an overview of Aruba's underwater cultural heritage in the form of the known, unknown, and future archaeological resources followed by chapter four explaining the threat factors affecting Aruba's underwater cultural heritage. Chapter five then expands on the importance of managing Aruba's underwater cultural heritage followed by a long-term management plan of Aruba's underwater cultural heritage in chapter 6. The discussion focuses on current points of debate present within the maritime and underwater archaeological field of Aruba. The final chapter is the conclusion, where a summary will be presented and the research questions answered followed by recommendations for future research.

[1] Gino Wauben is a local sport diver of Aruba.

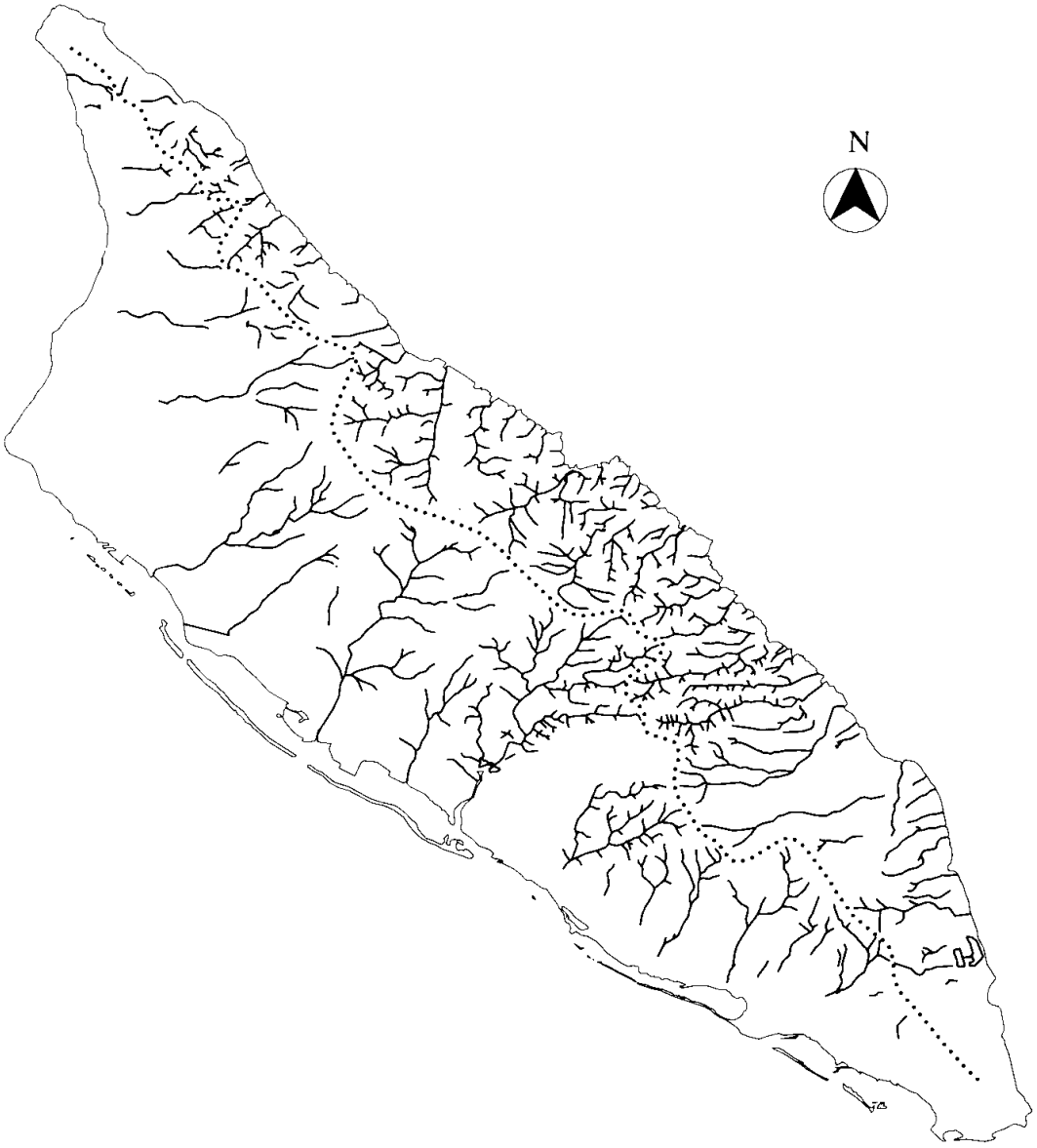


Figure 1. Map of Aruba portraying the Coastlines and inner water systems, called the "rooi systems". Source: Versteeg and Ruiz, 1995, p. 46.

Chapter 2 Aruba's cultural heritage

Cultural heritage is a term that is perplexing and complex to both researchers and the public alike. What is (underwater) cultural heritage and how can it be managed? These questions are aimed to be answered within this thesis report beginning with the definitions of (underwater) cultural heritage and its significance to the society within this chapter.

2.1 Cultural heritage

Cultural heritage is a broad concept. Heritage is defined as "something that someone or a collective considers to be worthy of being valued, preserved, catalogued, exhibited, restored, and admired" (Kersel and Luke, 2015, p. 71). Culture on the other hand is defined as "the product of human activity, particularly those things that are socially transmitted, including beliefs, practices, objects etc." (Appiah, 1994, p. 111-112; Scheffler, 2007, p. 107). Thus, cultural heritage is defined as a way of living which was developed by a community and was passed down from generation to generation. Cultural heritage is therefore a conscious decision made by a group of individuals in what is culturally important to keep alive throughout multiple generations, namely personal, social, political, and economic heritage (Hupperetz, 2015, p. 321). The developed way of living consists of customs, practices, places, objects, artistic expressions and values within a community. Cultural heritage could be either tangible or intangible, and thus not limited to monuments and collection of objects. In addition, cultural heritage is also comprised of living expressions which are inherited by the generation's ancestors. Tangible heritage are artefacts, buildings, landscapes, while intangible heritage include voices, values, traditions, and oral history. Intangible heritage is portrayed through cuisine, clothing, forms of shelter, traditional skills, technologies, religious ceremonies, performing arts, and storytelling. However, it must be noted that intangible heritage can be fragile but is crucial in maintaining cultural diversity. Tangible and intangible heritage are considered to be linked to one another (Culture in Development: http://www.cultureindevelopment.nl/Cultural_Heritage/What_is_Cultural_Heritage; Cultural Heritage: https://en.unesco.org/fieldoffice/santiago/cultura/patrimonio.; Hupperetz, 2015, p. 321).

However, it must be noted that what is considered cultural heritage today my change in the future. Heritage is a term that is always 'on the move', meaning that people may think differently in regards to what is considered heritage and this may change continuously based on the location, preservation status, time, knowledge, etc., which may influence the economic and historical value of the heritage. For example, businesses, the local communities, and the government value the underwater archaeological resources as it is visible within the underwater landscape and can be exploited for economic gain. However, if natural or human impacts affect the underwater resources, the value and subsequently what is considered heritage may change.

Culture heritage management

The goal of cultural heritage management is to develop a good balance between expanding and maintaining a good tourism industry, and to grow the economy while still maintaining and preserving the site and its history. In addition, the management of cultural heritage strives to promote educational, historical, and cultural values. What is crucial within cultural heritage management is to create a sustainable plan to manage the tourism industry and to ensure environmental protection. Thus, in order to manage the tourism traffic within the environment of the cultural heritage sites, environmental damage must be prevented in addition to taking climate change, pollution, loss of ecosystem, and keeping the preservation of the resources at sustainable levels into account. Collaboration work with stakeholders is a good way to yield concrete results as it gives stakeholders the feeling of empowerment in addition to solidifying relationships in order to create long-term sustainable development plans. In addition, educating is a key factor in managing heritage sites, as visitations to these sites are perceived as a threat to the preservation of the cultural and natural processes. Thus, why not use this prominent threat to the heritage as a protection resource instead (IESA Arts and Culture: https://www.iesa.edu/paris/news-events/cultural-management-definition).

2.2 Underwater cultural heritage

Underwater cultural heritage and the management thereof is still a relatively young theme within the underwater archaeological field. Underwater cultural heritage is described according to UNESCO as "all traces of human existence having a cultural, historical, or archaeological character which have been partially or totally underwater, periodically or continuously, for at least 100 years". However, Aruba also aims to protect submerged human evidence that are less than 100 years old, namely 50 years and older counts in Aruba as a cultural heritage, namely shipwrecks, and other archaeological evidence from the Second World War.

Thus, within this thesis report, underwater resources that are (partially) submerged for a minimum of 50 years are considered underwater cultural heritage (Dijkhoff *et al*., 2012, p. 43). What falls under underwater cultural heritage are namely sites, structures, buildings, artefacts and human remains, vessels, aircraft, other transportation vessels with their accompanying cargo and other contents, and objects from the precolonial era with their accompanying archaeological and natural context (Manders, 2021, p. 2).

Underwater cultural heritage management

Underwater cultural heritage management aims at creating a balance between protecting the underwater archaeological resources and maintaining the economic and touristic business within a region. Therefore, multiple characteristics need to be taken into account when aiming to successfully manage an underwater archaeological site, which are discussed within this thesis report. The importance of managing underwater archaeological resources has gained interest due to the increasing human exploitation and climate change (Manders, 2021, p. 3). This growing interest to protect and manage underwater cultural heritage expanded to Aruba due to the continuous expansion of the economic developments from the large yearly influx of tourist, and the change in climate occurring worldwide (Vermeij *et al*., 2020).

Underwater cultural heritage management can occur on a site, regional, or international level. Managing underwater cultural heritage at a site level entails the structure/object itself, while managing a site on a regional level includes the environment in which the cultural heritage is situated in. The environment where the underwater resources resides in plays a crucial role in its preservation and how the site needs to be managed. When managing a site at a regional level the following data are gathered, namely the historical background, if other adjacent sites are present, what the area where the underwater resource is currently located presently used for, what the threats are to the underwater resources, and who the stakeholders are. Managing a site at a national level is similar to a regional level. However, protective legislations is involved within the national level as well as the usage of a central database containing the known resources. Databases are important in managing sites as they provide an overview of not only the underwater archaeological resources but also the geology, history etc., which can be combined in a Geographic Information System (GIS). Lastly, underwater archaeological resources can be managed on an international level. Managing underwater archaeological resources at an international level creates possibilities for international cooperation as this is crucial for the scientific community in understanding and managing the underwater cultural heritage sites (Manders, 2021, p. 5-7).

2.3 Aruba's underwater cultural heritage framework

When aiming to manage an underwater cultural heritage site, the cultural heritage framework must be established within a population. The knowledge and significance of Aruba's underwater cultural heritage was analyzed within this subchapter using analysis, surveys and interviews conducted on various stakeholders (see table 1). The following stakeholders were chosen as they are organizations and parties who will be involved in managing Aruba's underwater cultural heritage, as would be explained below.

Table 1. Stakeholders involved in the management of Aruba's underwater cultural heritage. Source: Dijkhoff, 2020; Dijkhoff, 2023.

Sector	**Stakeholder**	**Role**
Government	Government: Ministry of Culture and Ministry of Justice	Funding and legislation
	Ministry of Tourism	Spreading awareness
	UNESCO Aruba	Funding and capacitation
	Department of Culture	Spreading awareness
	Department of Legislation and Legal affairs	Legislation
	Police and coast guard	Control and enforcement
	Marine base	Control and enforcement
	Shipping department	Control and enforcement
	Public ministry	Enforcement
	Council of Monuments	Nominating protected monuments
	Office of Monuments	Legislation, appointing, and preservation of protected monuments
	Department of Agriculture, Husbandry, and Fisheries	Public awareness and cooperation
	National Archaeological Museum Aruba	Spreading awareness and management
	Department of Education	Education in schools
	Department of Infrastructure and Planning	Zoning enforcement
	Department of Public Works	Control of construction in sea
Non-government	Rancho foundation	Spreading awareness and cooperation
	National Park Aruba Foundation	Managing Marine Park
	SS Oranjestad Memorial Committee	Diving expertise, equipment and network Spreading awareness and cooperation

	UNOCA, Prins Bernhard Fonds	Funding of educational and awareness projects and programs
Business	Aruba Tourism Authority	Spreading awareness
	Aruba Hotel and Tourism Association	Spreading awareness
	Aruban media	Spreading awareness
	Companies of renting equipment and tours on or under the sea	Spreading awareness and cooperation
	Hadicurari fisher's center	Spreading awareness, equipment capacitation and cooperation
	Dive schools/companies	Spreading awareness, equipment capacitation and cooperation
	Fishing companies and fishers	Spreading awareness, equipment capacitation and cooperation
Local	Local communities	Spreading awareness and cooperation

A stakeholder analysis was conducted within this sub-chapter where the significance and value of the underwater cultural heritage to the different stakeholders are shown below. However, it must be taken into account that the concept of 'value' does not have one set definition when conducting a stakeholder analysis. Whether a site or an underwater archaeological resource has value to a person or a community is determined by the person or community themselves as it is usually linked to one's culture or identity. Significance or value is put into a contemporary, scientific, or social context. In addition, the value of a site/ underwater archaeological resource differs depending on the perspective, current and future usage of the heritage and surrounding environment. The main purpose of this stakeholder analysis was to establish the relationship between the different stakeholders and identify the significance of the underwater archaeological resources in order to determine the role the stakeholders will play in managing Aruba's underwater cultural heritage. When determining what should be managed, the choice relies on the different definitions on the concept of significance or value the different stakeholders have for the underwater archaeological resources, on who has a right to determine the value, whether the value depends on the usage of the site/ underwater archaeological resource, does it have a cultural or economic significance, and how does this differentiation play a role in the assessment and management of Aruba's underwater cultural heritage. The identified stakeholders within this thesis report each had personal motivations in regard to the management of the underwater cultural heritage. Financial, moral, ethical, political, and business interests were observed during the interviews and surveys.

However, the significance of each stakeholder is also linked to one another when it comes to managing the underwater cultural heritage. The stakeholder analysis was divided into the following sectors, namely government, non-government, business and locals.

The government sector, namely ministers, departments, government offices, and the museum are tasked with the responsibility of keeping Aruba and its accompanying cultural heritage up and running. Given the fact that Aruba's main source of income is through tourism, it is therefore crucial that they play a role in the management of the underwater cultural heritage. A portion of the underwater archaeological resources present in the waters of Aruba function as popular dive and snorkel locations. In addition, the government can take advantage of the fact that underwater archaeological resources are being used as dive and snorkel locations as this creates opportunities to educate tourists and locals about Aruba's history. The government stakeholders are responsible for the funding, legislation, capacitation, control and enforcement, spreading awareness and educating the local communities, and cooperation of the underwater cultural heritage. Thus, the stakeholders that form part of the government value the resources through both its cultural as economic significance as Aruba's underwater cultural heritage is one of the largest source of income for the island through tourism, in addition to creating educational opportunities. The non-government stakeholders view Aruba's underwater cultural heritage as a part of Aruba's history and culture and should be kept alive for generations to come. Thus, non-government stakeholders have a moral, ethical, and cultural interest in Aruba's underwater cultural heritage. Therefore, the stakeholders identified and chosen for this thesis report are focused on educating, spreading awareness, managing and funding projects and programs that brings light to the importance of Aruba's underwater cultural heritage. The underwater cultural heritage of Aruba is important for the local businesses as this is their livelihood, their main or only source of income. Local businesses that are related to the maritime and underwater landscape have therefore a financial, moral, ethical, and business interest in regard to the management of Aruba's underwater cultural heritage. Local businesses are important stakeholders as they have direct contact with the locals and tourists and can spread awareness directly to the source.

Cooperation between the government, non-government and local businesses are crucial as the government sets and enforces the legislations in addition to funding the management and preservation of the underwater cultural heritage. The non-government stakeholders in turn takes on the role to educate and spread awareness on the legislations and importance of Aruba's underwater cultural heritage. The value the underwater archaeological resources have for the tourist industry, diving, and fishermen companies have a direct influence on the financial income gained through the exploitation of said underwater archaeological resources.

When the local businesses value the importance of managing the underwater archaeological resources, they ensure that themselves, tourists and locals who visit the sites treat it with respect and do not cause harm or damage. This in turn ensures the continuation of financial gain for the government stakeholders.

Lastly, a survey was distributed island wide among the locals living in Aruba. The survey asked participants questions about their demographic (name, age, born in or immigrated to Aruba), knowledge on the underwater archaeological resources, threats to the underwater archaeological resources, and how these can be managed/preserved. What was made clear from the results of the surveys, is that the local communities has the basic knowledge of what Aruba's underwater archaeological resources are based on the popularity of the dive and snorkel sites, and sees said dive and snorkel sites as a part of Aruba's cultural history. However, there is still a clear lack of knowledge on what underwater cultural heritage entails, the preservation status, and the chemical, biological, and human activities that are degrading or causing damage to the underwater archaeological resources. When informed with the fact that the underwater archaeological resources are being threatened, the local communities show a need and want to protect and manage these sites for future generations. The local communities believe that the underwater archaeological resources can be managed through the implementation of stricter guidelines within the dive and tourist industries regarding what the visitors can and cannot do. In addition, protective measures surrounding the shipwrecks and dive sites should be incorporated to prevent damage to the exterior of the resources. Raising awareness and spreading knowledge also forms an important part in the management and protection of the underwater archaeological sites. This can be achieved, according to the local communities, through the educational programs and implementing said educational programs within social media, the school system, presentations etc. On a more island-based level, the local communities feel the need to implement laws, and checkups on the status of the underwater archaeological resources as well as human activities that have a direct impact on the sites. The questionnaire of the surveys and results of the survey are presented in appendix 1 and 2.

The end goal for involving the stakeholders is to provide information and to create a support system in case measures need to be taken or information needs to be gathered. The involvement of stakeholders is to ensure that the underwater archaeological resources are protected together. This establishes that a sustainable heritage plan through the four most used pillars, namely "understanding", "valuing", "caring", and "enjoying" can be created (see figure 2). The four pillars are called the heritage cycle, and the main objective is to make people understand the historical environment so they can in turn appreciate it and value it (Thurley, 2005).

As was mentioned within this sub-chapter, different values were attributed to the underwater archaeological resources and sites, and that the different values of the stakeholders influence one another. However, what are Aruba's underwater archaeological resources? The known, unknown (potential), and future underwater archaeological resources of Aruba are portrayed in chapter 3: Aruba's underwater cultural heritage.

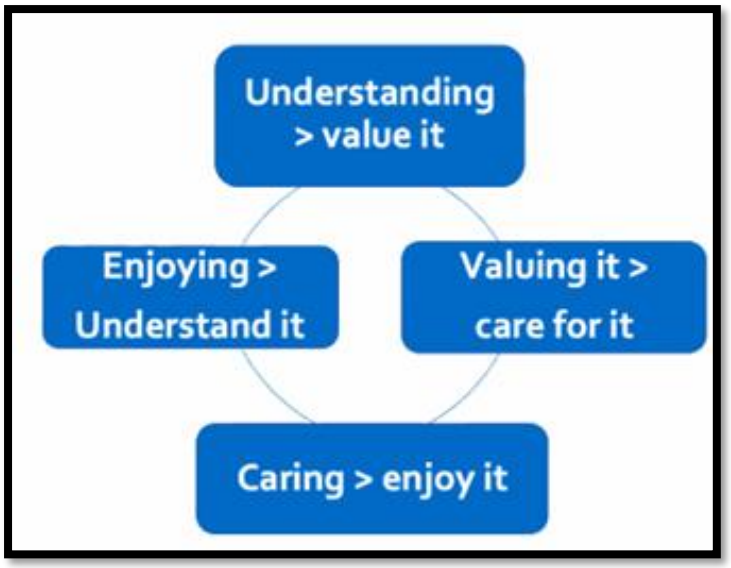


Figure 2. The Heritage cycle. Source: Thurley, 2005

Chapter 3 Aruba's underwater cultural heritage

Before delving into Aruba's underwater cultural heritage and underwater archaeological resources, it is important to establish the definition of underwater archaeological resources. One definition is given within this thesis report, namely by the USA Archaeological protection Act of 1979:

Any material remains of past human life or activities which are of archaeological interest. Non-fossilized and fossilized paleontological specimens, or any portion or piece thereof, shall not be considered archaeological resources, unless found in an archaeological context. No item shall be treated as archaeological resources unless such item is at least 100 years old.

USA Archaeological Protection Act of 1979

Thus, (underwater) archaeological resources are defined as the materials left behind underwater or on land that is now submerged by humans in the past (Manders, 2021, p. 2). However, the minimum age to be considered an archaeological resource in Aruba is 50 years and older (Dijkhoff *et al*., 2012, p. 43). Aruba's underwater archaeological resources are divided into three categories, namely known, unknown, and future resources. The underwater archaeological resources date back to three main time periods, namely the Archaic (1500 BC – 900/1000 AD), Ceramic (900/1000 AD – 1515 AD), and the Historic/Modern period (1515 – 1973). The Historic/Modern period consists of a broad timeline and is therefore split into five sub-periods (see table 2). The official time frame for the Historic period is up until 1986. However, based on the fact that Aruba considers underwater archaeological resources 50 years and older as heritage, the end of the Historic period within this thesis report was cut off at 1973 as these underwater resources are 50 years and older (see chapter 3.3: Future underwater archaeological resources).

Table 2. The three main times periods of habitation in Aruba. Source: Digital files available at the National Archaeological Museum Aruba, Oranjestad, Aruba.

Time period	**Sub-category time period**	**Dating range**
Archaic period	-	1500 BC – 900/1000 AD
Ceramic period	-	900/1000 – AD – 1515 AD
Historic period	Spanish period	1515 – 1636
	Dutch West India Company	1636 – 1791
	Colonial period	1792 – 1924
	Industrial period	1924 – 1986
	Modern period	1987 – Present

3.1 Known underwater archaeological resources

The known archaeological resources entail all the known archaeological sites that were found and are still present in-situ (Manders, 2021, p. 5). A total of seventeen known underwater archaeological resources were found and documented in the surrounding waters of Aruba (Dijkhoff, 2021), with eight from the precolonial period (Archaic and Ceramic periods), and nine from the Historic period (see table 3). A database was created for this thesis report in which the heritage type, specifications/material type, location, depth, time period, status, threat factors, and whether it is protected and by whom they were documented (see attachment 1). The location of the known underwater cultural resources are portrayed in figure 4 .

All the precolonial sites (Archaic and Ceramic period sites) discovered were identified as potential (temporary) settlements containing varying amounts of shells, shell fragments, stones, corals, pottery and pottery fragments (see figure 3) (Physical files available at the National Archaeological Museum Aruba, Oranjestad, Aruba). The known underwater archaeological resources pertaining to the Archaic period are largely located in the northwest of the island in the region between the coast of *Arashi* and *Palm Beach* (see figure 4). The known underwater archaeological resources of the Ceramic period are situated in the northwest and west regions of the island with two underwater sites identified at *Palm Beach* and *Mangel Halto* (see figure 4). In addition, three submerged precolonial sites were identified at *Malmok* in which it could not be determined whether it was from the Archaic or Ceramic period (see figure 4).

Figure 3. Precolonial site in situ portraying the remnants left behind. Source: Dijkhoff, 2021.

Table 3. Overview of the locations and site types of the known underwater archaeological resources. Source: Dijkhoff, 2021.

Time period	**Location**	**Site type**
Archaic/Ceramic period	Malmok	Settlement
Archaic period	Arashi	Settlement
	Palm Beach	Settlement
Ceramic period	Palm Beach	Settlement
	Mangel Halto	Settlement
Historic period	Spaans Lagoen	Harbor
	Savaneta	Harbor
	Noord	Shipwreck
	Malmok	Shipwreck
	Palm Beach	Shipwreck
	Sero Colorado	Shipwreck
	Sero Colorado - Natural bridge	Shipwreck
	Eagle Beach	Shipwreck
	Baby Beach	Religious symbol

The Historic period sites discovered were identified as two harbors, six shipwrecks, and one religious symbol (Physical files available at the National Archaeological Museum Aruba, Oranjestad, Aruba). The locations of the known underwater archaeological resources dating back to the Historic period are all present on the leeward side of the island, with the exception of one shipwreck situated at natural bridge of *Sero Colorado* (see figure 4). The harbors were located on the west side of the island, namely *Spaans Lagoen* and *Commandeursbaai*. Surveys conducted on the two harbors revealed a total of 27 sites containing archaeological artefacts. Anchors, bottles, ballast stones, a possible cannon, and concrete wood dating back to the early Historic period between a depth of zero to six meters, and construction materials, a fishing trap, a floating platform, a fiber boat shipwreck, industrial materials, and bottles dating back to the later periods situated at a depth of one to six meters were found at *Spaans Lagoen*. The artifacts found at *Commandeursbaai* were bottles, remains of old harbor buoys, a military helmet, a leather shoe, admiralty stock anchors, a possible car wreck, the blade of a propeller, a ballast stone, and the remains of a fiber boat situated between a depth of two to five meters and date back to the early to later Historic period.

Thus the timeframe of these artefacts span between the 17th and 20th centuries (Symister and Dijkhoff, 2022), indicating long term various activities taking place on the west side of the island, especially when combining this information with the locations and types of shipwrecks documented within historic resources (see attachment 1).

The one shipwreck from the Colonial period sank off the coast of the northside of the island at the *Hudishibana* dunes as it could not see the shoreline as the island lacked a lighthouse (Dijkhoff, 2021). The shipwreck sites entails one shipwreck from the Colonial period and five from the Industrial period. During World War II, the Germans organized an attack on Aruba which formed a part of a bigger attack project, namely Operation Paukenschlag. Operation Paukenschlag was an organized attack that lasted from January to June 1942 in the East coast of the United States and the Caribbean Sea, as the Caribbean was under a relatively strict unilateral command of the American and Dutch headquarters. The attacks resulted in hundreds of ships sinking and thousands of soldiers dying with 47 of them being from Suriname and the Antilles. The results of Operation Paukenschlag on Aruba was the attack on three ships (Alofs and Merkies, 2001, p. 50; Oorlogs Bronnen, thema: Operatie Paukenschlag: https://www.oorlogsbronnen.nl/thema/Operatie%20Paukenschlag.; U.S. Army Center of Military History: Chapter XVI The Caribbean in Wartime: https://history.army.mil/; Hochstuhl, 2001). The SS Antilla sank after an escape attempt at the beginning of the war, and the SS Oranjestad sank in 1942 off the coast of *Sero Colorado*. The ships SS Pedernales and SS Arkansas were attacked by torpedoes in 1942 but managed to stay afloat. However, (significant) damage were done to the ships and large sections of ship remnants broke away and sank to the seafloor at *Eagle* and *Palm Beach*. In addition, anchors, nails, a rudder, and ship engine artifacts were found from one shipwreck at the Natural bridge of *Sero Colorado*. However, the exact type of ship and when it was built and subsequently sank could not be determined.

Known underwater archaeological resources

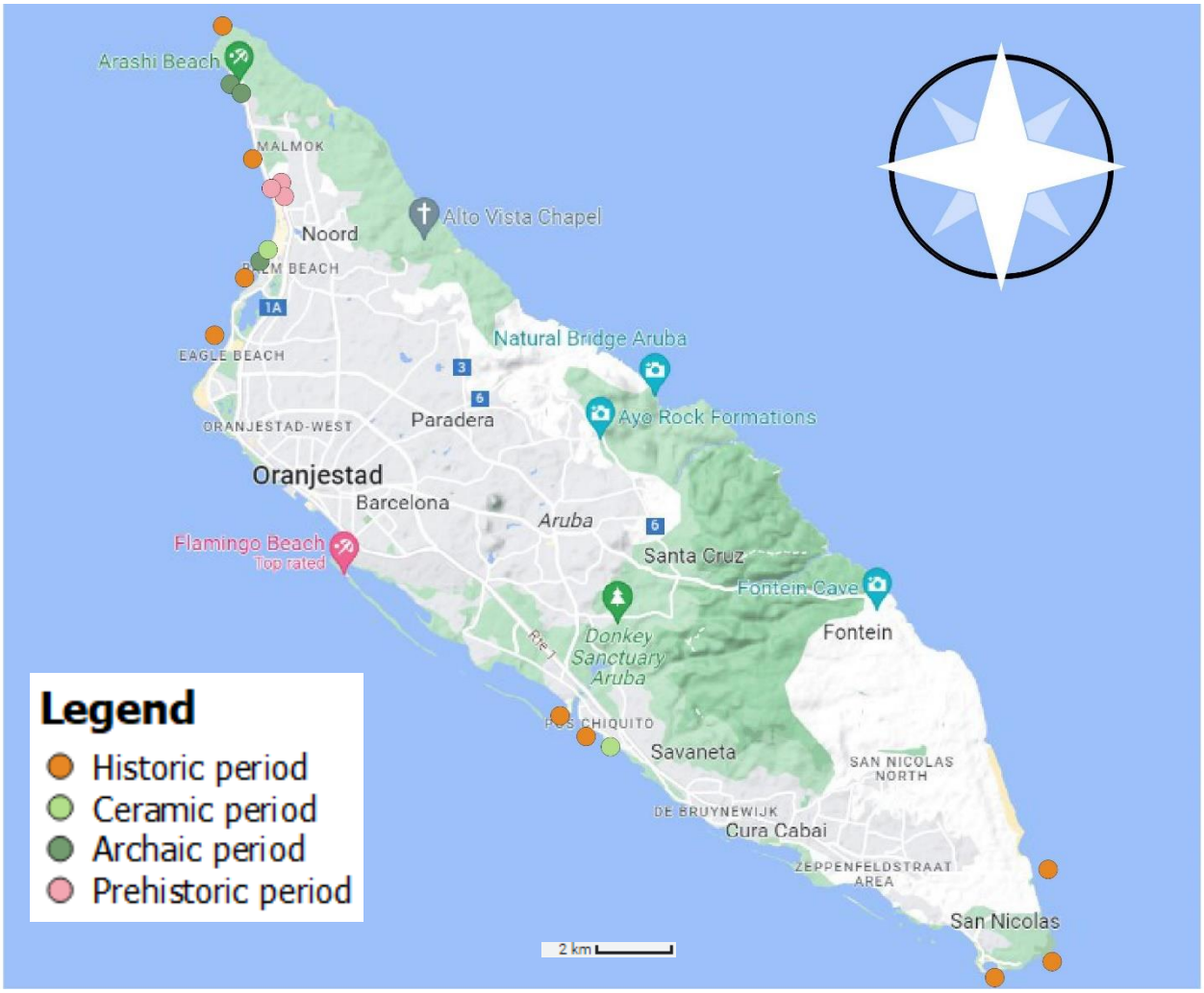


Figure 4. Topographic map of Aruba portraying the locations of the known underwater archaeological resources. Source: Digital files on hand, National Archaeological Museum Aruba, Oranjestad, Aruba. Map created by Gendra Laclé.

3.2 Unknown underwater archaeological resources

Maritime and underwater cultural heritage are strongly linked to the landscape. A landscape contains specific qualities that in turn determine how people used that area. The usage of the landscape gives insight into how it was altered by people in order to fit their needs, as this makes it possible to predict the locations for potential underwater archaeological resources. Predictions can be made on the probability of underwater sites by looking at the landscape as the distribution of underwater sites follow certain patterns. How did it look like in the past, how was it used, how did it change as time went on, and how did these changes influence the individuals that came to the island? (Manders, 2017, p. 50).

Thus, when aiming to determine the potential (unknown) underwater archaeological resources, the maritime landscape was analyzed for the Archaic (1500 BC – 900/1000 AD), Ceramic (900/1000 AD – 1515 AD), and the Historic/Modern period (1515 – 1973).

The maritime landscape was defined by C. Westerdahl in 1978 and 1980 as "the whole network of sailing routes, old as well as new, with ports and harbors along the coasts, and its related constructions and remains of human activity, underwater as well as terrestrial" (Westerdahl, 1992, p. 6). The maritime landscape was analyzed based on historical maps. However, due to the lack of historical maps and information of the landscape during the Archaic and Ceramic periods, maps dating back to the Historic period were analyzed starting from the Dutch West India Company period onwards. Predictions were then made in regards to how the landscape may have looked during the Archaic and Ceramic periods. Historical maps were not available during the precolonial period as these individuals did not have the resources to create maps. The lack of historical maps during the Spanish and Dutch West India Company period could be attributed to the lesser economic value Aruba had for the Spanish and Dutch in addition to its lack of fortifications which came after the Company era. When the Spanish arrived, they deemed the island useless and proceeded to capture and deport as many indigenous people as they could to Hispaniola (Hartog, 1961). Afterwards, the Spanish were only interested in using Aruba for its beneficial geological location in regards to the trade industry with Venezuela (Alofs and Dalhuisen, 1997). When the Dutch West India Company took over Aruba, they proceeded to use the island for cattle breeding and to raise livestock, namely cattle, goats, pigs, sheep, and horses (Teenstra, 1836; Hartog, 1953). Therefore, the earliest map of Aruba used within this thesis report was a historical map from 1773 created by Engelbertus Horst, a captain lieutenant.

After the geological and ethnographical information is gathered from the three time periods, the historical background and photographs, in addition to archaeological evidence are put within this context in order to predict the potential (unknown) underwater archaeological resources. Thus, when determining the potential (unknown) underwater archaeological resources, account was taken with the locations of the known underwater archaeological resources of the Archaic, Ceramic, and Historic periods as these portray an indication of the possible presence of more or other underwater archaeological resources, in addition to taking the land archaeological artefacts into account. However, at minimum a portion of the potential (unknown) archaeological resources may be buried in the sea floor or have (partially) disappeared due to environmental and human threat factors (see chapter 4: Threats to Aruba's underwater archaeological heritage).

3.2.1 Aruba's geological data

The geology and sediment formations on the coastlines provide insight into the nature, age, and preservation of the potential underwater archaeological resources present within the landscape. The coastline consists of geological soils dating back to the Holocene, Pleistocene, and the Cretaceous period, with the majority of the soils being from the Holocene and Pleistocene. The soils from the Holocene period consists of alluvial mud and sand, calcareous beach and dune sand, and coral reefs. The soils from the Pleistocene are shallow marine limestones, limestones lithified with calcareous dune sand, and hornblende tonalite, conglomerate, and dolerite from the Cretaceous period. However, the majority of the coastline soils consist of Holocene and Pleistocene soils (see figure 5).

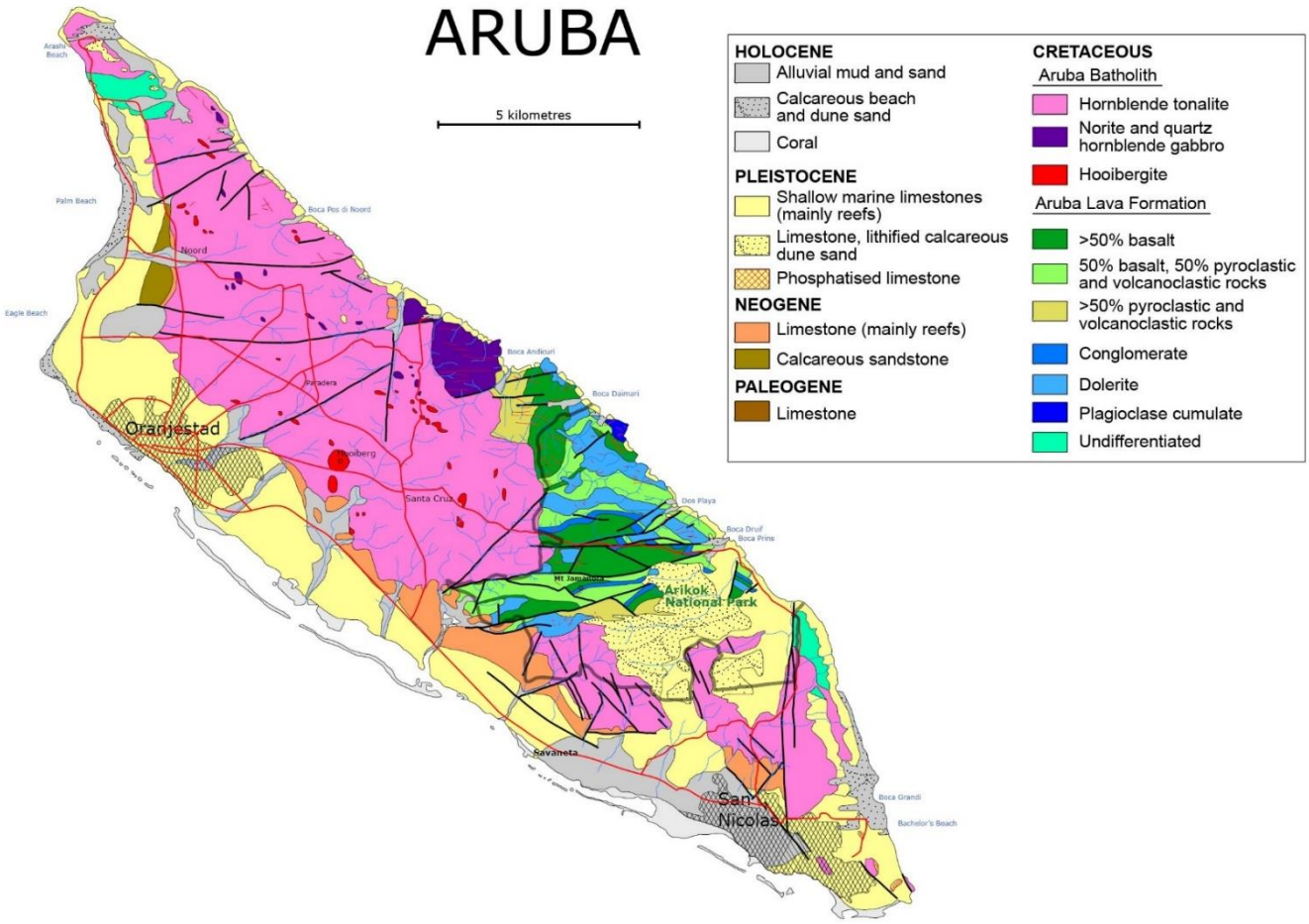


Figure 5. Geology map of Aruba. Submitted by Peter Verweij on 29-11-2017 in the Dutch Caribbean Biodiversity Database.

3.2.2 Archaic period

The first inhabitants of Aruba were indigenous people who were considered to have migrated from South America (Kelly and Hofman, 2019, p. 155; Dijkhoff and Linville, 2004, p. 5). The inhabitants survived by exploiting and consuming terrestrial and marine resources, namely shellfish, fish, sea turtles and their eggs, herbs, seeds, snails, and small game. They lived in small bands of ten to fifteen people following a semi-nomadic lifestyle staying relatively close to the coast or inland gullies (Boerstra, 1982, 1990; Dijkhoff and Linville, 2004, p. 5; Kelly and Hofman, 2019, p. 148).

Archaeological evidence portrays how different regions of the island were used for different activities with the *Malmok* and *Spaans Lagoen* coastlines and inner water ways having a longer usage timespan, due to the easy accessibility to this part of the maritime landscape, namely shallow calm waters where the individuals could sail smoothly with their small vessels (Versteeg and Tacoma, 1990; Nooren, 2008; Antczak *et al.,* 2018, p. 125; Kelly and Hofman, 2019, p. 154-155). The historical data indicating long term usage of the coastlines on the leeward side of the island coincides with archaeological evidence, namely activity sites found. As was mentioned above, three known underwater archaeological sites dating back to the Archaic period are now (partially) submerged. The settlements/activity sites were found in close proximity to the sea at *Malmok*, *Arashi*, and *Palm Beach*, in addition to settlements along inner banks at *Spaans Lagoen* and *Bringamosa* (see figure 6). The location, reliability, and extensive usage of the coastlines and waterways can leave behind archaeological evidence that this landscape was used. The sites contained shells and shell fragments, pottery and pottery fragments, stone and stone tools, which can be expected to be found at the potential locations still remaining undiscovered. Thus, based on the historical maps portraying the landscape characteristics, the historical data expanding on the way of life of the individuals dating back to the Archaic period, that the settlements were situated on sand covered and shallow marine limestones (see figure 5), and based on the archaeological evidence found it could be speculated that the leeward side of the island can be suspected to contain potentially undiscovered underwater archaeological resources, making it an archaeologically valued region. Specifically, the region between *Palm Beach* and *Arashi*, and the west coastline containing the barrier reef with a higher chance at *Spaans Lagoen* (see figure 7). However, this did not take into account the threat factors, this is expanded on in chapter 4: Threats to Aruba's underwater archaeological heritage.

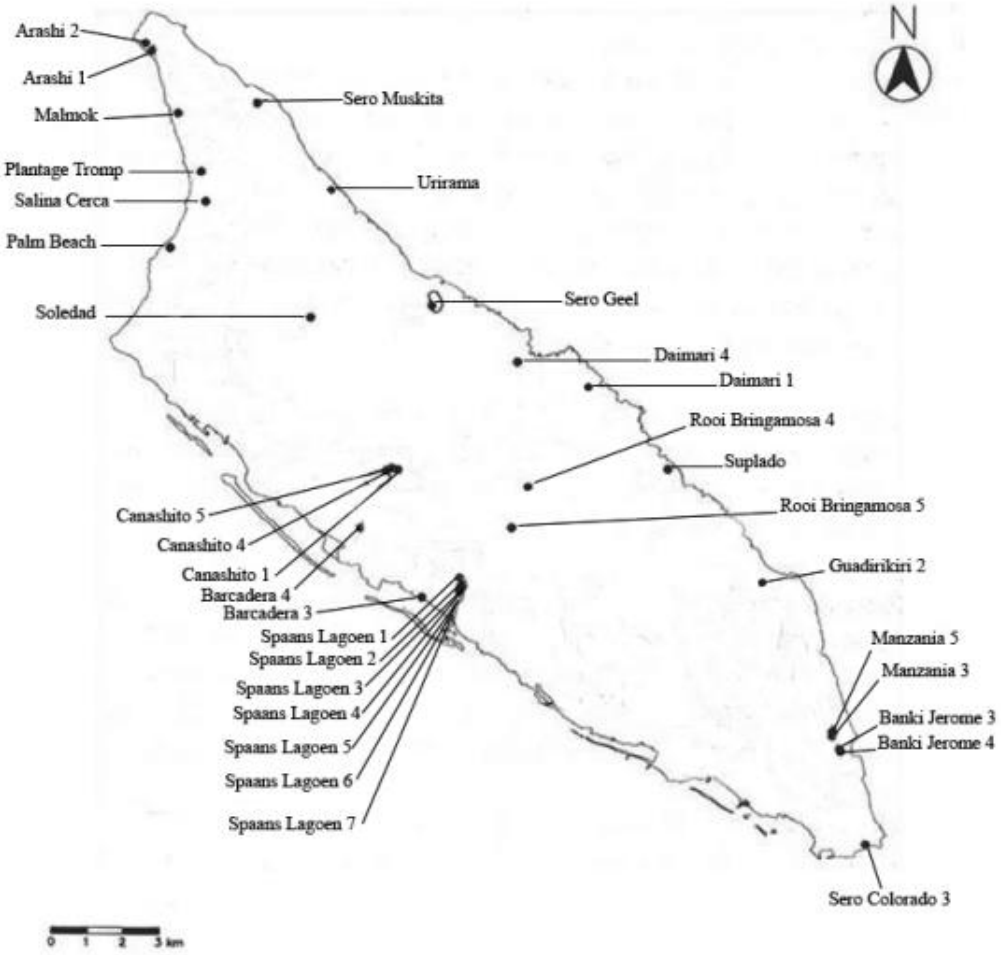


Figure 6. Map of Aruba showing the Archaic sites found on Aruba. Source: Kelly and Hofman, 2019, p. 149.

Uknown Archaic period underwater archaeological resources

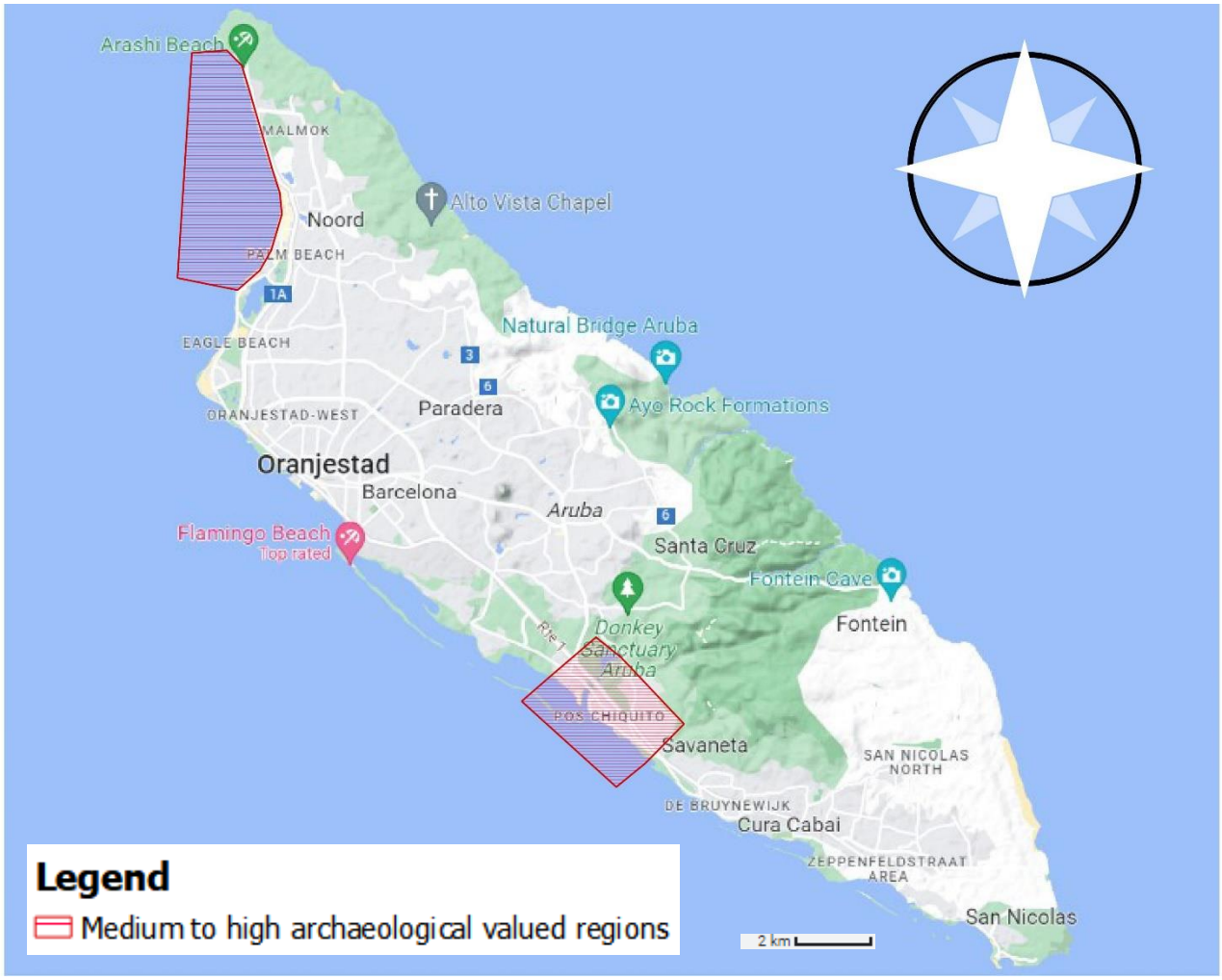


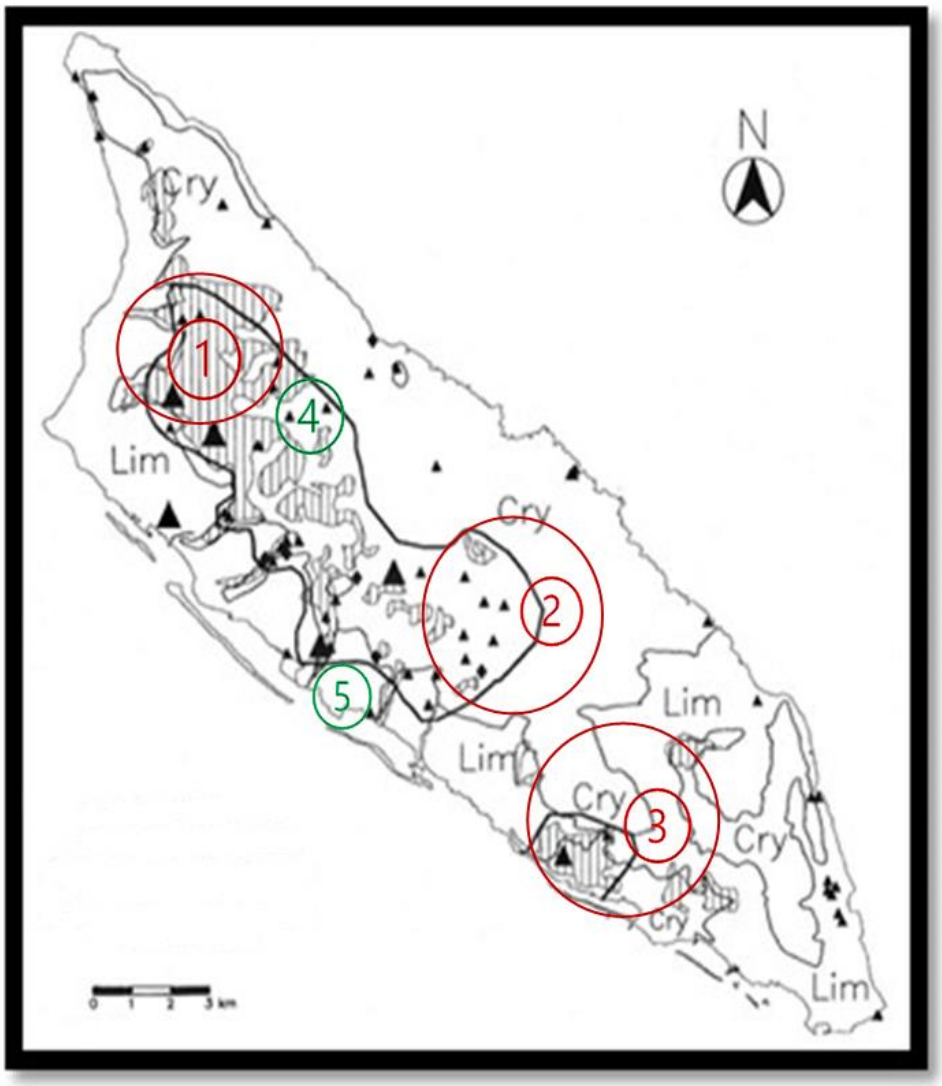
Figure 7. Topographic map of Aruba portraying the high suspected locations where possibly unknown (potential) underwater archaeological resources dating back to the Archaic period are present. Map created by Gendra Lacle.

3.2.3 Ceramic period

The group of indigenous people that lived on Aruba during the Ceramic period were known as "Dabajuran" or "Caquetio" people who began migrating to the island around 900/1000 AD (Dijkhoff and Linville, 2004, p. 5-6). The individuals lived in permanent settlements in the inner regions of the island, namely at *Tanki Flip* situated in the northern part of the island, in *Santa Cruz*, situated in the middle of the island, and in *Savaneta*, located in the lower southwest coastal region. Two additional smaller settlements were located at *Tanki Lender* and *Parkietenbos*, with a third possible settlement in *Oranjestad* (see figure 8) (Dijkhoff and Linville, 2004, p. 5-6; Dijkhoff *et al.,* 2010). However, the natural resources on the island were still continuously being exploited with the individuals consuming fruits, turtles and their eggs, iguanas, birds, small mammals, fish and shellfish.

The settlements contained 'catchment areas' and (temporary) activity camps were scattered throughout the entire island. The 'catchment areas' and (temporary) activity camps formed part of the network for fishing and collecting shellfish, collecting fruits and vegetables from the landscape, and agricultural activities (Dijkhoff and Linville, 2004, p. 6.; Kelly, 2012, p. 54). When looking at the archaeological artefacts found at the settlements dating back to the Ceramic period, evidence of trade between Aruba, the Peninsula of Guajira in Colombia and the Peninsula of Paraguana in Venezuela were observed. Remnants of pottery decorated with avemorphic motifs were found at *Santa Cruz* and *Savaneta*, and they share similarities to a specific pottery type found in the valley of La Guaijra, Colombia (Kelly, 2012). In addition, trade with the Venezuelan mainland was determined by the presence of Dabajuroid-style pottery found in Aruba which shares similarities to ceramics found in Venezuela (Veth, 2012). Given the fact that *Commandeursbaai* is situated at the primary coastline settlement, archaeological evidence of the trading that occurred between Aruba, Colombia, and Venezuela could still be present in or on the seabed at this harbor. Lastly, the maritime landscape characteristics and way of life during the Ceramic period, it is speculated that *Paardenbaai* was used as an activity site in the exploitation of marine resources, as it was an easily accessible shallow region (Symister and Dijkhoff, 2022).

When combining the landscape characteristics, maritime landscape, the way of life of the indigenous people with the known underwater archaeological resources and terrestrial settlements, and the archaeological evidence found, patterns emerge in regards to possible coastline activity sites. Activity sites were found at *Malmok*, *Palm Beach* and *Mangel Halto* situated on sand covered and shallow marine limestones, indicating that the activity sites stretched further northwest as this landscape was also shallow with natural sandbanks, and further west in the vicinity of the main village *Savaneta*. The known sites in turn coincides with the (permanent) villages, namely the northwestern region is close to the possible village of *Oranjestad* and *Mangel Halto* is close to *Commandeursbaai* situated at one of the main villages which was *Savaneta*. Based on this information, the leeward side of the island can be suspected to contain potential underwater archaeological resources, specifically the area between *Malmok* and *Paardenbaai*, *Oranjestad* and the region at *Mangel Halto* and *Commandeursbaai* (Symister and Dijkhoff, 2022) (see figure 9 and appendix 3). Dense distributions of shells and shell fragments, coral, stone, pottery and pottery fragments can be expected at the potential underwater archaeological sites. However, this does not take into account the threat factors that may have a played a role in the preservation of the potential archaeological materials (see chapter 4: Threats to Aruba's underwater archaeological heritage).



Legenda

1. Tanki Flip
2. Santa Cruz
3. Savaneta
4. Tanki Lender
5. Parkietenbos

Figure 8. Locations of the Ceramic period sites found in Aruba that were to the inhabited by the Dabajuran/Caquetio people. The sites used within this study are encircled. Source: Dijkhoff and Linville, 2004, p. 5-6; Dijkhoff, 2023.

Uknown Ceramic period underwater archaeological resources

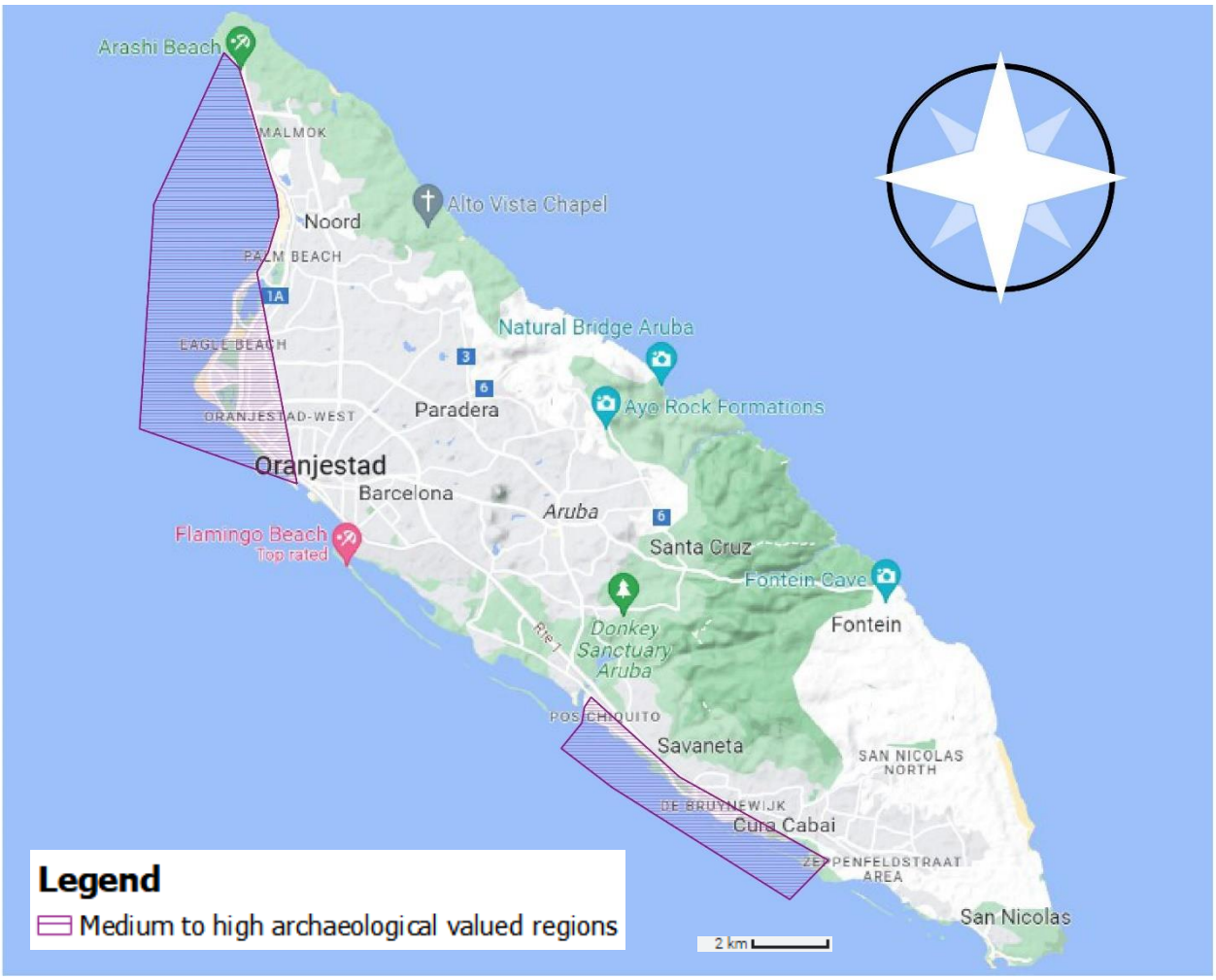


Figure 9. Topographic map of Aruba portraying the high suspected locations where possibly unknown (potential) underwater archaeological resources dating back to the Archaic period are present. Map created by Gendra Lacle.

3.2.4 Historic period

The Historic period is known for the (slave) trade within the Caribbean, gold mining, phosphate harvesting, and oil trading (Alofs and Merkies, 2001). In addition, continuous and increasing trade occurred between Europe, Latin America, and Aruba (Hartog, 1953; Hartog, 1961; Haviser, 1991; Kelly, 2012, p. 50; Vermeij *et al.*, 2020, p. 9). Within this sub-chapter, the Historic period was divided into four periods, namely the Spanish period, the period of the Dutch West India Company, the Colonial period, and the Industrial period (see table 2).

Spanish period

Water traffic was minimal during the Spanish period as the Spaniards were solely interested in the island for its beneficial geological location in the trade industry with Venezuela. However, continuous migration, mobility, and trade occurred between the indigenous people of Aruba and Venezuela during this period. The island was solely used by the Spaniards in the exportation industry of brazilwood, kwihi[2], and divi divi (Watapana tree)[3] up until 1533 (Hartog, 1961). Between 1533 and 1636, multiple Spanish ships came to Aruba to bring goats, sheep, horses, donkeys, cows, pigs, oranges, pomegranates, lemon trees, and sugar to the island (Hartog, 1953, p. 34; De Palm, 1985, p. 186). However, aside from this, the island was seldom visited by the Spaniards (Alofs and Dalhuisen, 1997). During the Spanish period, the indigenous people lived mainly in *Savaneta* and between *Piedra Plat* and *Noord* (Hartog, 1953, p. 37-38; Nooyen, 1962, p. 9). Therefore, it could be speculated that the wood exportation industry took place at *Commandeursbaai*, in addition to the bay being used as the main harbor, and is situated on the southwest coast of Aruba at *Savaneta* on soils consisting of alluvial mud and sand (Angela, 2001, p. 1). Thus, potential underwater archaeological resources can still be present at *Commandeursbaai* and *Spaans Lagoen* but have yet to be discovered dating back to 1515 – 1636 (see figure 10). The archaeological materials expected to be found are mostly ship and ship material remnants, in addition to personal household materials used on board (see appendix 3).

[2] The kwihi is a relatively fast growing shade tree that can be used as firewood. It is one of Aruba's native species.

[3] The divi divi, otherwise known as the watapana tree that contain tannin substances that can be harvested and traded.

Uknown Spanish period underwater archaeological resources

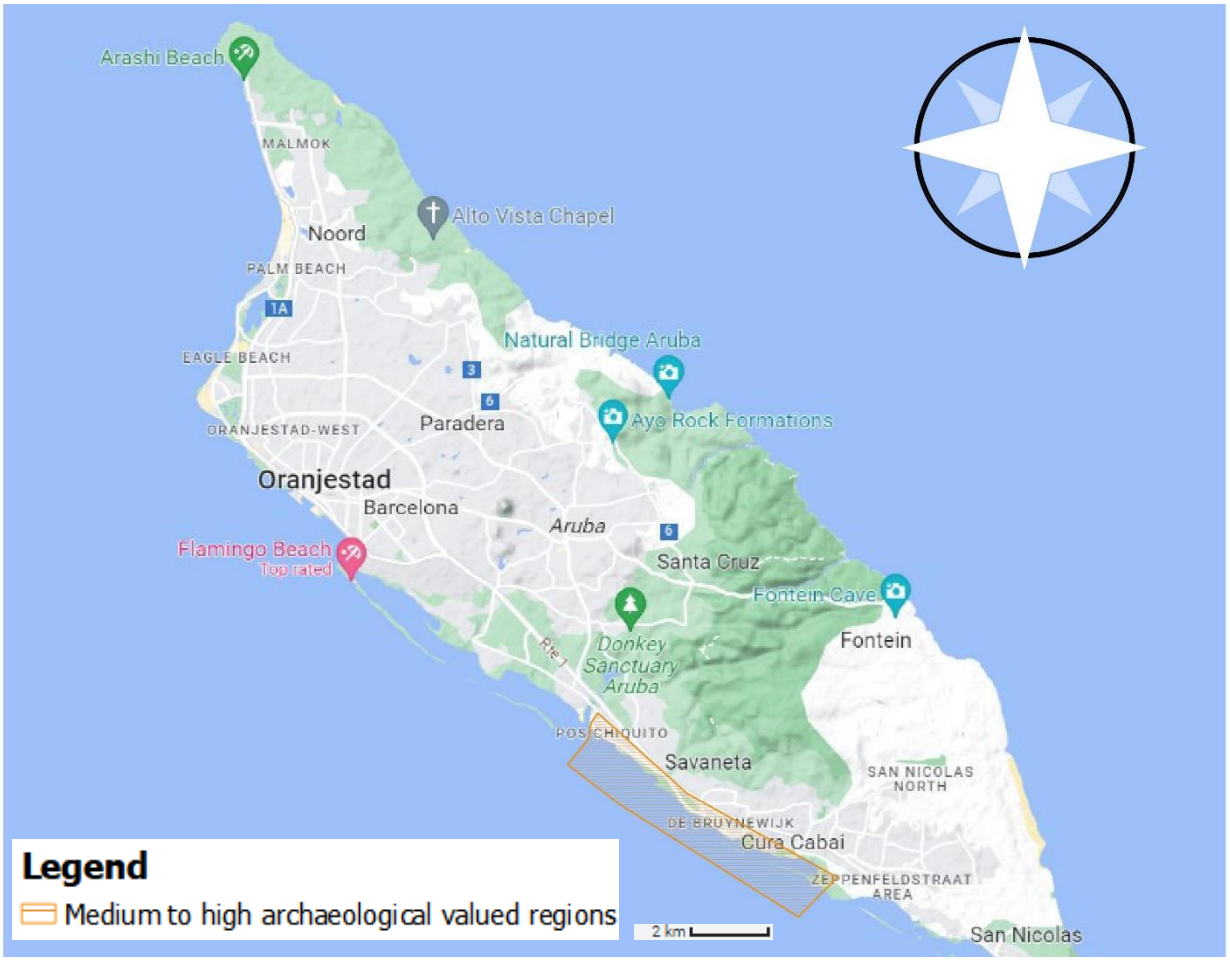


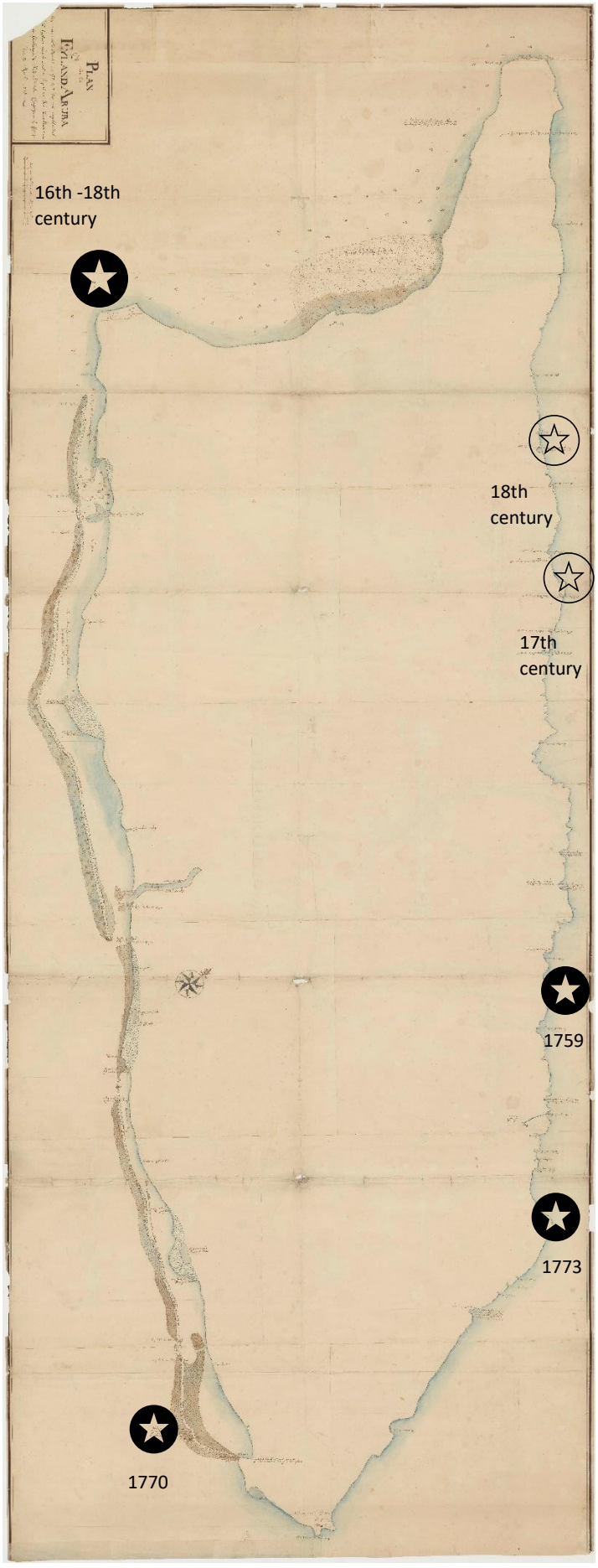
Figure 10. Topographic map of Aruba portraying the high suspected locations where possibly unknown (potential) underwater archaeological resources dating back to the Spanish period are present. Map created by Gendra Lacle.

Dutch West India Company

In the beginning of the Dutch West India Company (WIC) period, namely between 1640 – 1754, the island was sparsely inhabited due to a ban on permanent settlement. The small group of Europeans who resided on the island lived at *Commandeursbaai* (Hartog, 1961; Alofs and Merkies, 2001, p. 12). The indigenous people lived in the vicinity of *Savaneta*, *Santa Cruz* and *Fontein* during the 17th century and gradually migrated to the north side of the island as time went on (Alofs and Merkies, 2001, p. 13-14). During this period, Aruba was used in the harvesting and exportation of salt. Salt was an important product to have on board of WIC ships as it was used in the preservation of food (Alofs and Merkies, 2001, p. 11). During the 17th and 18th century, salt was harvested off the coast of *Rodgers beach* between the barrier reef and the coast.

Based on the map of Engelbertus Horst 1773, only small and flat vessels could enter through *Commandeursbaai* and travel to *Rodgers beach* (Source: National Archief, 4.VEL[1584/1865]: NL-HaNA_4VEL_649, inv. nr. 649 - Plan van het Eyland Aruba, opgenomen met de planchet, door Engelbertus Horst, Capitain Lietenant en Ingenieur). Larger vessels sailing close to the barrier reef at Rodgers beach could get stranded due to the sand bays. This coincides with the documentation of a potential ship that was stranded west of *Rodgers beach* (see figure 11) (Source: National Archief, 4.VEL[1584/1865]: NL-HaNA_4VEL_649, inv. nr. 649 - Plan van het Eyland Aruba, opgenomen met de planchet, door Engelbertus Horst, Capitain Lietenant en Ingenieur). Therefore, this region may have suspected archaeological materials that were left behind dating back to the Dutch West India Company period (1636 – 1791). However, the waters surrounding the entire island was utilized during the Dutch West India Company period. The northwest coastline spanning from *Eagle beach* to *Arashi beach* was used for ship anchoring as this region was shallow with calm waters, and ships entered the island on the westside of the island through *Paardenbaai* and *Commandeursbaai*, also making it a high valued region containing possible archaeological materials (see figure 12). However, the region outside the barrier reef of *Paardenbaai*, *Oranjestad* has a higher chance of containing archaeological remains than the region inside the barrier reef due to human activities and coastal developments. The eastside of the island was also used by the Europeans. Before colonization became possible in 1754, *Alto Vista* became a notable region for residency for the individuals that inhabited the island due to the fact that a water well, named *Pos di Noord* was situated within this region. However, the landscape surrounding *Alto Vista* was a fairly wooded area during the 16th century (Alofs and Merkies, 2001, p. 14). This area therefore became an attractive bay and eventual harbor for ships to dock as they can acquire freshwater here (van der Klooster and Bakker, 2013). This information is corroborated by the documentations made on the map created by Engelbertus Horst in 1773, in addition to ethnohistorical documents of shipwrecks. Figure 11 portrays the following potential underwater archaeological resources that were found to be documented on this map, in addition two potential underwater archaeological resources were found documented within ethnohistorical literature. The specified archaeological expectations for the Dutch West India Company period are presented in appendix 3.

An unknown galleon wreck is documented to be present at a distance of 1500 – 2000 meter from the coast of Manchebo beach.



It is documented that a Cuban vessel stranded at Boca Pos di Noord. Boca pos di Noord was an attractive location for ships as it was used as an unofficial "harbor" to collect water

It is documented within the AHATA map that the remains of an unknown 17th century wreck is located in front of Boca Grandi and Boca Cura at a distance of approximately 500 – 750 m from the coast.

It is documented that two possible vessels were stranded at Boca Keto, namely "Twee Sand Baaijen (illegible)" and the "Fluijters" abandoned by soldiers from the garrison in Curaçao.

It is documented "Place where the vessel of Wilhem Welvaart stranded at a small cove near the Quadirikiri cave.

It is documented "Place marked with a cross where a galleon had sailed circa 1770 and the ship was subsequently stranded".

Figure 11. Plan of the island Aruba, recorded with the planchet and created by Engelbertus Horst, Captain Lieutenant and Engineer. Source: National Archief, 4.VEL[1584/1865]: NL-HaNA_4VEL_649, inv. nr. 649 - Plan van het Eyland Aruba, opgenomen met de planchet, door Engelbertus Horst, Capitain Lietenant en Ingenieur. URL: https://www.nationaalarchief.nl/onderzoeken/archief/4.VEL/invnr/649/file/NL-HaNA_4.VEL_649.

Uknown Spanish period underwater archaeological resources

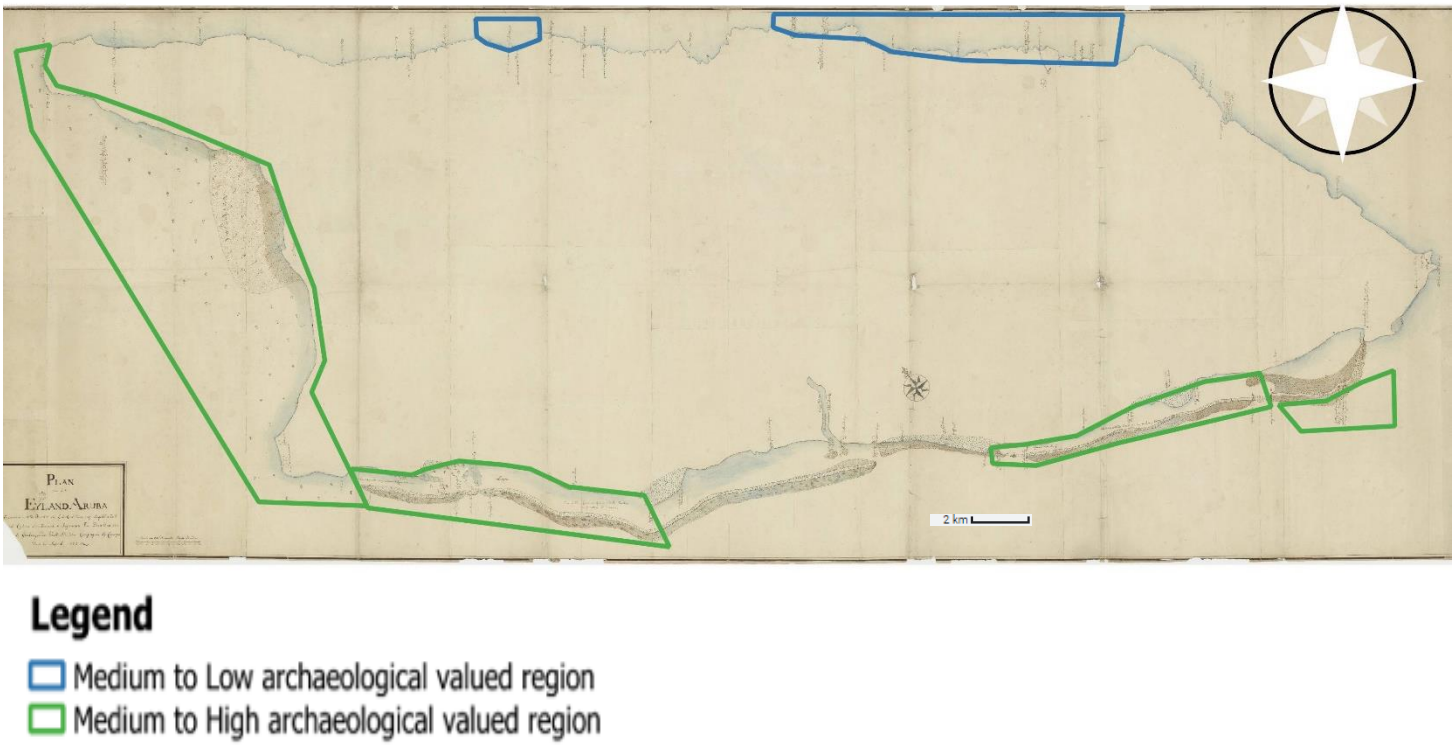


Figure 12. Historic map of Aruba portraying the high suspected locations where possibly unknown (potential) underwater archaeological resources dating back to the Dutch West India Company period are present. Map created by Gendra Lacle.

Colonial period

The usage of the harbor at *Oranjestad* became more prominent after the liquidation of the West India Company as Aruba was compelled to focus on the community as the population was expanding (van der Klooster *et al*., 2007, p. 59). European migration to Aruba increased after 1754, and became even greater after 1785 when a land tax was put in place making it easier to acquire a license and settle in permanently on Aruba (Hartog, 1961; Alofs, 1996; Martis, 2018). In addition, the years 1792 – 1816 were considered years of confusion and war as Aruba was under the control of different countries. In the beginning of the turbulent years, the stealing of ships docked at *Paardenbaai* was attempted by the English but failed (Menkman, 1942, p. 188). This lead to the built of a small fortification in 1798 called *Fort Zoutman* at *Paardenbaai* armed with four guns (Hartog, 1953, p. 75; Menkman, 1942, p. 193; Bosch, 1985). However, this was not sufficient to protect the island against attacks, and in 1799 three ships carrying ammunition were sent to *Paardenbaai* to build its defense. In the same year of 1799, the English attacked *Fort Zoutman* (Bosch, 1985, p. 154-160; Hartog, 1953, p. 92). Another attack took place in 1805, however this time it was from the Dutch on *Fort Zoutman* who was then under control of the English.

This attack took place on land and sea and lasted two days, afterwards the English surrendered but they soon returned and attacked again end of 1805 but were defeated after a short battle. A final attack took place in early 1806 when the English returned with a larger army leading the inhabitants to escape into the woods. However, afterwards, the English left (Bosch, 1985, p. 160-163; Hartog, 1953, p. 96-100). Between 1803 – 1816 Aruba changed hands twice between the English and the Dutch (Hartog, 1961; Martis, 2018). The constant wars and attacks depleted the resources leading to all the goats and sheep disappearing, and only a small amount of usable wood was left on the island (Hartog, 1953), decreasing the attractiveness for ships to come to the island for meat or wood. Based on the continuous fight for Aruba and the multiple attacks, potential archaeological remnants of the attacks could be present at *Paardenbaai*.

Aside from the attacks and battles that took place at *Paardenbaai*, they bay was also used as a warehouse at the end of the 18th century. In addition, free trade was permitted in Aruba in 1796, which catapulted the mercantile industry (Bakker and Van der Klooster, 2008, p. 6), and from 1795 onwards traders and craftsmen came and traded at *Oranjestad*. The harbor of *Paardenbaai* was chosen to become the trading centrum over *Commandeursbaai* due to the better accessibility for ships and taking in the fact that trade was prohibited at this bay (Alofs and Merkies, 2001, p. 16-18), and became a hub for the transportation of horses (Alofs, 2018). This in turn coincides with the documentations made on the map created by Engelbertus Horst 1773, in which it is stated that the entire west to south coastline was extensively used as the sailing routes in addition to the region to enter Aruba. *Paardenbaai* was suitable for large ships with throw anchors. Southeast of this harbor is a lagoon, separated from the harbor by a sand bank accessible by small and flat sailing ships (see figure 13). The *Commandeursbaai* on the other hand was only accessible by small flat ships (see figure 14) (National Archief, 4.VEL[1584/1865]: NL-HaNA_4VEL_649, inv. nr. 649 – Plan van het Eyland Aruba, opgenomen met de planchet, door Engelbertus Horst, Capitain Lieutenant en Ingenieur).

From 1816 onwards, Aruba fell under the Dutch rule and this brought forth a period of stability for the inhabitants (Hartog, 1953). However, the first few years after 1816 were difficult. The amount of goats and sheep were completely depleted and therefore would take a few years to become profitable once again, agriculture occurred on a smaller scale in comparison to other regions, and the fishing industry and salt pans did not yield sufficient resources to sustain the communities (Alofs and Merkies, 2001, p. 26). Between 1816 – 1929 Aruba participated in the agro-mercantile industry as the climate and soil on the island was not beneficial for plantations. Trade occurred at *Oranjestad* and this eventually became the capital of Aruba in 1824 (Hartog, 1953, p. 175-176).

Figure 13. Map of Aruba circa 1773 portraying the accessibility of Paardenbaai harbor. Source: National Archief, 4.VEL[1584/1865]: NL-HaNA_4VEL_649, inv. nr. 649 – Plan van het Eyland Aruba, opgenomen met de planchet, door Engelbertus Horst, Capitain Lieutenant en Ingenieur. URL: https://www.nationaalarchief.nl/onderzoeken/archief/4.VEL/invnr /649/file/NL-HaNA_4.VEL_649

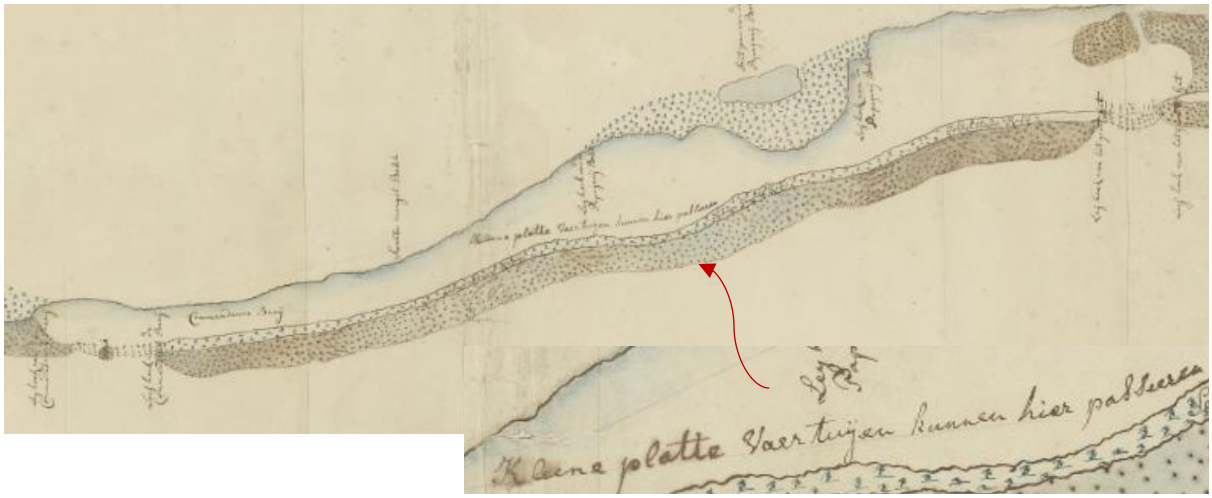


Figure 14. Map of Aruba circa 1773 portraying the accessibility of Commandeursbaai harbor. Source: National Archief, 4.VEL[1584/1865]: NL-HaNA_4VEL_649, inv. nr. 649 – Plan van het Eyland Aruba, opgenomen met de planchet, door Engelbertus Horst, Capitain Lieutenant en Ingenieur. URL: https://www.nationaalarchief.nl/onderzoeken/archief/4.VEL/invnr /649/file/NL-HaNA_4.VEL_649

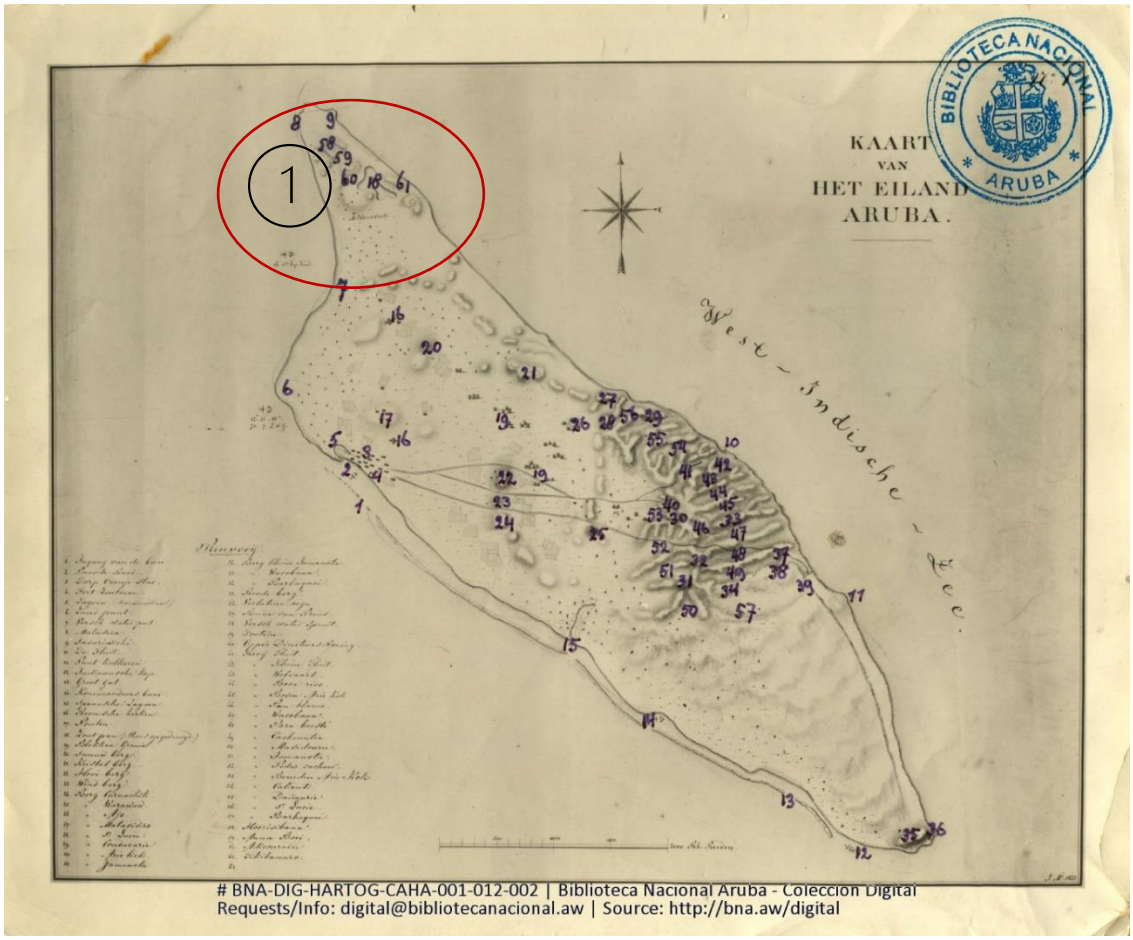
Between 1820 and 1837, the following products were exported gathered from the island itself, namely horned cattle, sheep, poultry, Brazilwood, aloe and after 1824 gold. The exportation of goods was then rewarded with the importations of food, clothing, tools, etc. (Alofs and Merkies, 2001, p. 18). Two periods of prosperity for the communities of Aruba occurred between 1824 – 1832 and 1868 – 1915/1916 through gold mining, and 1881 – 1915 through phosphate winning (Hartog, 1980, p. 154-156). However, the first gold period did little to improve the economic situation on the island (Alofs and Merkies, 1990, p. 27, 35-37). In addition, aloe also became popular during this period and remains popular to this day (Alofs and Merkies, 2001).

The two gold smelters in the second gold period were located at Bushiribana and Balashi. The first gold was discovered in 1824 in een "*rooi*"[4] called *Fluit* in the north side of the island. This inner water system was named after a late 16th century Dutch ship type called the "Fluyt" (Ship Types: https://www.dhm.de/mediathek/en-ship-types/milestones-in-the-history-of-european-shipbuilding/09-fluyt/#.~:text=Late%20in%20the%20sixteenth%20century,other%20vessels%20of%20the%20time.). Gold nuggets weighing up to several kilograms were found. After the first gold nuggets were discovered, a ban was put up by the government. Positive results were achieved in the first few years, however it was decided to outsource after 1829. Private individuals were allowed to search for gold with the exception that the gold is traded through the government at two-thirds the value. This continued until 1832, when gold became scarce and could no longer be found (Alofs and Merkies, 2001, p. 27). Starting from 1854 onwards, the extraction of gold began again in the hills on the north side of the island located at *Bushiribana*. The concessionaire F. Isola managed to extract gold in a profitable manner between 1868 – 1872. However, the mines were temporarily closed until 1878. After the mines were reopened, the business succeeded so much that foreigners had to be employed. The Arubans themselves preferred to work at the aloe-cutting plants as this was a better paid job. After the gold plant was still in use between 1895 – 1899, it was decided to move the gold industry to the south coast of the island. The Aruba Goldmining Company built a smelter at *Balashi* located at the southern end of Frenchman's pass, and functioned from 1899 – 1916 (Arubiana: https://arubiana.com/place/balashi-gold-mills-ruins/; Alofs and Merkies, 2001, p. 29). This location was chosen due to its easy connection with the sea. Following the opening of the smelter at *Balashi*, mines were opened throughout the entire island to extract gold. However, the increase in cost forced the company to sell the smelter to the Aruba gold company in 1908, and following World War I, the company ceased operations as the workers no longer felt that their efforts were properly rewarded and the processing aids could no longer be obtained (Alofs and Merkies, 2001, p. 29). Following the second gold period on Aruba, the first pier was placed at the harbor of *Paardenbaai*. During the construction of the pier, archaeological materials were found from the precolonial period, namely urns, which were subsequently lost (Hartog, 1953).

[4] A rooi is an inner water system of Aruba similar to a small (dry) river.

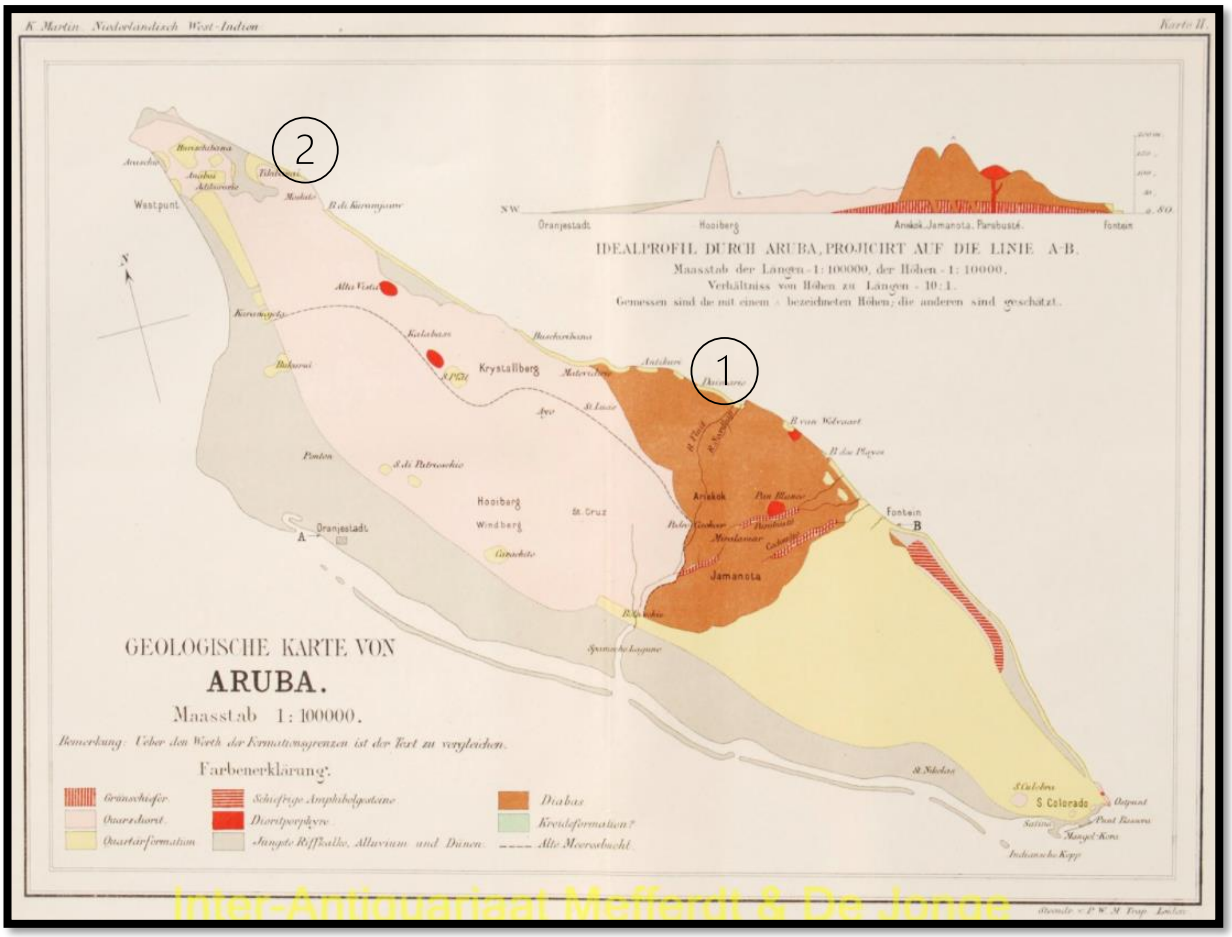
Phosphate was discovered on Aruba in 1874 at the southeast point but was not mined until 1881 by the *Aruba Phosphaat Maatschappij* (Alofs and Merkies, 2001, p. 30). The phosphate found were namely phosphatized limestone layers from guano droppings dating back to the late Pleistocene (Ridderstaat, 2007; Derix, 2016, p. 1874). The phosphate was excavated and exported to north America and northwestern Europe where it was processed into fertilizer. However, the market position quickly deteriorated when phosphate was also found in Florida and Algeria around 1893. This led to a decline in the selling prices. It was also at this time that they had to switch to underground extraction of the phosphate which in turn increased operation costs. In 1902, the freight rates declined, in turn making it cheaper to transport phosphate from Florida, Algeria, and Tunis to farther destinations. The supply of auxiliary materials stopped during World War I which in turn forced the closing of the phosphate company in June of 1915 (Alofs and Merkies, 2001, p. 30).

Based on the historical documentation, the north, northeast, and east side of the island was also used as a potential sailing route. However, this was proven to be a dangerous route by the presence of two cargo ships and one warship shipwrecking on the northeast/east side of the island (see figures 15 and 16). The east side is the windward side which in turn has a hostile water environment where ships can lose their rudders and shipwreck. In addition, when tropical storms or hurricane pass in the vicinity of the island, this can create an even more hostile environment where ships can capsize and shipwreck.



1. *It is documented that In 1815 or 1823, the warship "Newark" stranded and broke down in the north shore of Aruba.*
   Source: Nooyen, 1962.

Figure 15. Historic map of Aruba circa 1825 portraying a documented possible shipwreck in the north coast of Aruba. The numbers on this map represent the different cities and activity sites on the island during the 19th century that are described in the legend within the map. However, the legend is not legible. Source: Internet Archive, BNA-DIG-HARTOG-CAHA-001-012-002. URL: https://archive.org/details/BNA-DIG-HARTOG-CAHA-001-012-002.



1. *The German Brig "Hero" was caught in a hurricane in the year 1886 and sank off the coast of Andicuri. Source: Nooyen, 1969.*
   Dijkhoff et al., 2012.
2. *The cargo brig "Rosa Helena" was transporting cargo of logwood in 1904 where it lost its rudder and wrecked between Druif and Urirama beach. Source: Nooyen, 1969.*

Figure 16. Historic map of Aruba circa 1888 created by Martin portraying the locations of possible archaeological remains based on historical documentation. Source: Internet Archive, BNA-DIG-KOSTBARE-0068-II. URL: https://archive.org/details/BNA-DIG-KOSTBARE-0068-II.

Thus, the focus region during the Colonial period was *Oranjestad*, namely *Paardenbaai* as this was the central point for trade, in turn creating constant water traffic in the northwest and west region of the island. Therefore, it is understandable why the attacks and battles took place at this region. In addition, ships did sink at *Paardenbaai* (Dijkhoff, 2021). This in turn makes *Paardenbaai* and the northwest sandbank high suspected regions for archaeological materials (see figure 17), more specifically materials from war activities, ship remnants, trading remnants, and ship household and personal materials, in addition to construction materials.

In addition, the northeastern point of Aruba would have been an attractive location due to the water well. Therefore, anchors, ship materials, and ship remnants could be present at the north side of the island, especially given the rough waters which in turn can make it difficult for captains to maintain control of their vessels. However, these hostile environments also play a role in why this region is categorized as a low valued region for suspected archaeological remains (see figure 17). The specified archaeological expectations are for the Colonial period are presented in appendix 3 .

Uknown Colonial period underwater archaeological resources

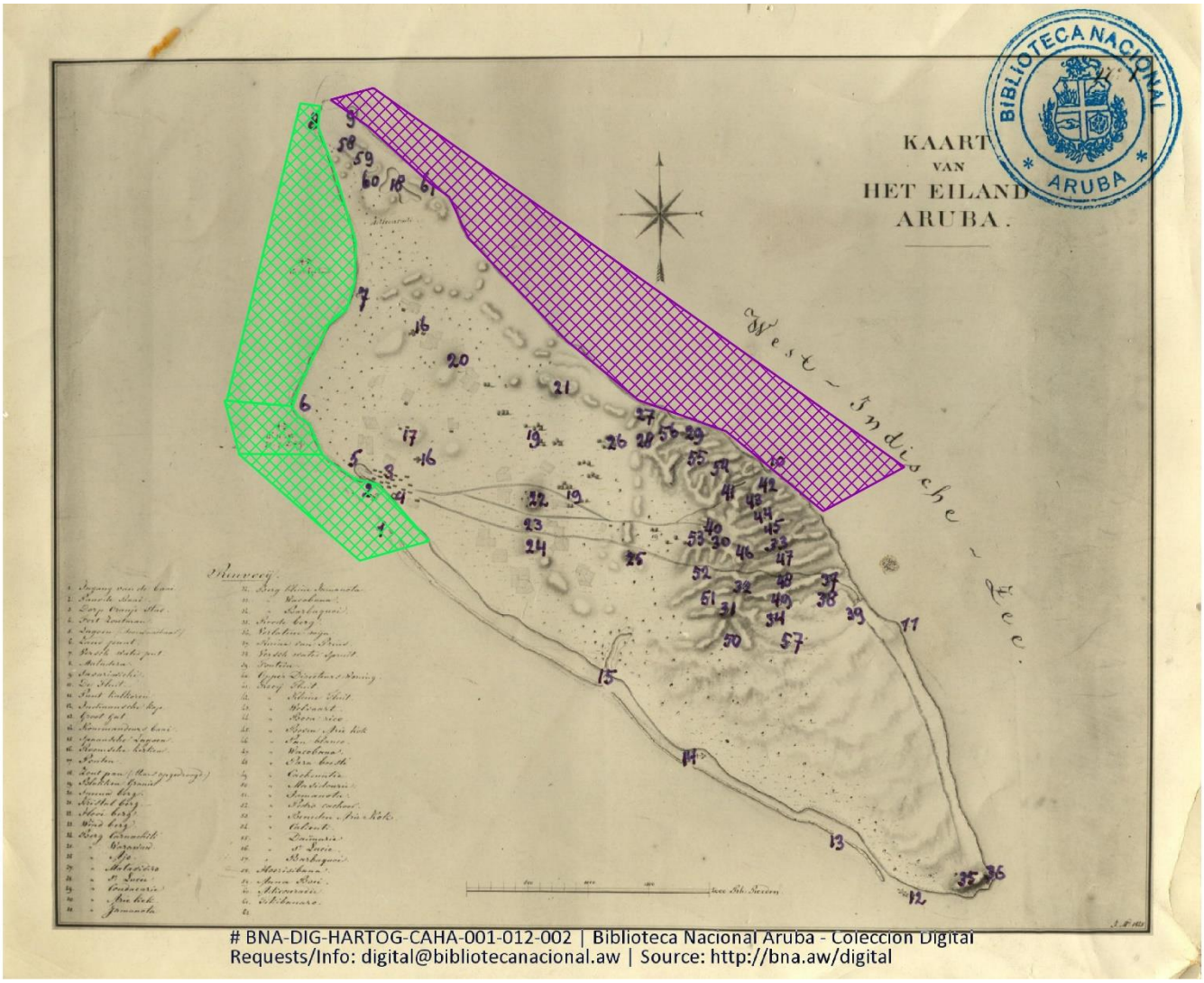


Figure 17. Historic map of Aruba portraying the high and low suspected locations where possibly unknown (potential) underwater archaeological resources dating back to the Colonial period are present. The numbers on this map represent the different cities and activity sites on the island during the 19th century that are described in the legend within the map. However, the legend is not legible. Source: Internet Archive, BNA-DIG-HARTOG-CAHA-001-012-002. URL: https://archive.org/details/BNA-DIG-HARTOG-CAHA-001-012-002. Map created by Gendra Lacle.

Industrial period

The industrial period of Aruba is characterized by the oil industry. The oil age in Aruba began in 1924 with the built of the first oil refinery, namely *Lago Oil Refinery* at the southeast point of the island with its accompanying harbor (see figure 18). The refinery slowly grew into a successful business and reached its peak during World War II, in addition to a colony forming at the most eastern point of the island (Alofs and Merkies, 2001; Dijkhoff, 2021). However, before the storage tanks at the refinery were ready, the steamship Invergarry of the *Lago Oil and Transport Company* was stationed at *Oranjestad*, where they made use of a pier at *Taratata* where ships could moor. Starting from 1925 onwards, construction began on the harbor at *San Nicolaas*, and it was finished in 1927. Port improvements began in 1937 with the deepening of the western port entrance and continued until after World War II (see figure 19). The port improvements entailed digging through the reef to make the port easier to enter, even at night. After World War II, the attention was turned to the harbor at *Oranjestad* where larger piers were built to accommodate the growing need for more capacity (Historia di Aruba: http://www.historiadiaruba.aw/index.php?option=com_content&task=view&id=28&Itemid=42; Dijkhoff, 2021).

Figure 18. A historical photograph portraying the Lago Oil Refinery with its harbor. Source: Oorlogs Bronnen, term: Aruba; https://www.oorlogsbronnen.nl/bronnen?term=aruba&page=1&tab=foto.

Figure 19. .Lago Oil Refinery Pier and harbor 1930's. Source: Dijkhoff, 2021.

Another oil refinery was built in 1927 west of *Oranjestad* named *N.V. Arend Petroleum Maatschappij* (Ridderstaat, 2007). Following the built of the oil refinery, the shell oil terminal pier and harbor were built near *Punta Brabo*, in the region of *Eagle beach*, with its accompanying office and railroad (see figure 20). Further construction on the pier began in 1930 and the new L-shaped pier open in 1931, followed by more extensions on the pier.

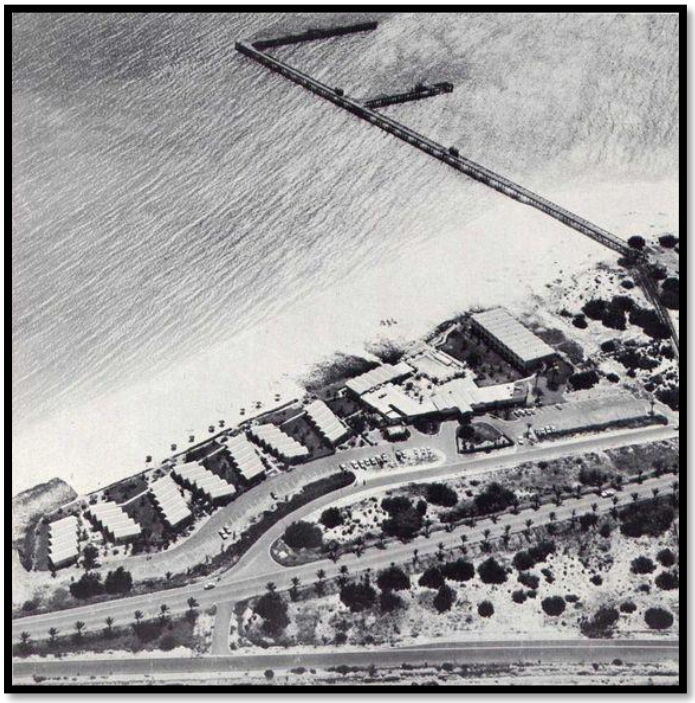


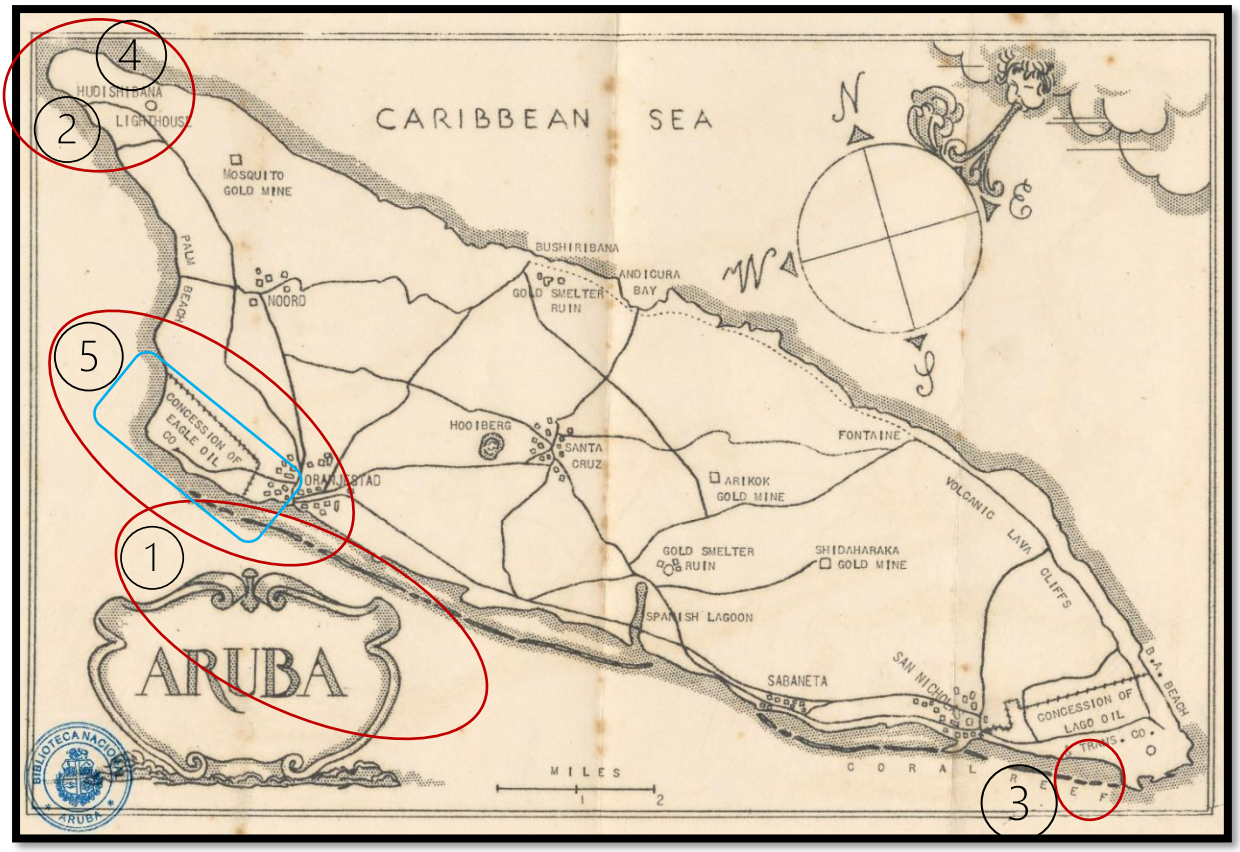
Figure 20. A Shell Oil Terminal pier Eagle Beach. Source: Dijkhoff, 2021.

The shell oil terminal pier functioned as an anchorage and docking location from 1927 – 1953 (Dijkhoff, 2021). However, the demographic and economic impact was less in comparison to the oil refinery located at *San Nicolaas*, and it eventually closed down in 1953 (Alofs and Merkies, 1990; Van der Klooster and Bakker, 2013, p. 19). Two docks were built at *Rodger's beach* during the 1940's presumably to accommodate the growing water traffic to and from Aruba during World War II. The first dock was a T-shaped dock with a platform on the side where boats can dock to either conduct repairs or shade from the sun. At a distance of circa 365 meters west and situated parallel of the T-dock was the big dock which contained no beach, solely coral cliffs (Lago Oil and Transport Co. Ltd.: https://lago-colony.com/).

During World War II and onwards, different types of vessels sailed to and from Aruba, namely freighters/cargo ships, steamships, oil tankers, and airplanes (see figure 22). Up until 1948, the *Paardenbaai* was entered through the north side as the west side was too shallow. Entering the harbor required difficult and sometimes dangerous maneuvers. In order to make this harbor more accessible, construction began in the form of dredging. The harbor of *Paardenbaai* was dredged at four different time periods, namely in 1916, 1930, 1939, and from 1947-1948, and at the end the depth was eleven meters deep, which is further expanded on in chapter 4. Before 1930, the harbor at *Paardenbaai* consisted of four individual harbors where different sized vessels can dock. However, only one of the four was accessible for cargo vessels, namely the harbor called "waf di Rey". In 1930, dredging occurred in order to deepen the harbor and to create a pier with a length of 140 meters (see figure 21) (Awe Mainta, 2021).

The focus region during the industrial period was at *Oranjestad*, *Paardenbaai* and *San Nicolaas*, where oil tankers continuously came to the island and docked either at *San Nicolaas* or *Oranjestad*. When taking the known and documented potential vessels that sank during the Industrial period into account, a pattern can be seen for clustering at *Paardenbaai* and the northwest sandbanks, and *San Nicolaas*, namely the coast of *Sero Colorado* and *Rodger's beach*, making these regions suspected high to low valued regions for archaeological materials. However, the region at *San Nicolaas* has a higher potential due to the multiple dredging projects that occurred at *Paardenbaai* during this period (see figure 23).

Figure 21. Paardenbaai after 1930 when the large pier was built. Translation of this photograph "the ocean used to reach up to where the Weststraat crossed paths with Havenstraat behind the Royal Plaza. Paardenbaai after the construction work and the completion of "Waf Grandi" in 1930". Source: Awe Mainta, 2021.



1. *The German freighter "SS Troja" was sunk 11 nautical miles west of Aruba following an escape attempt as a result of World War II in 1940.*
   Source: https://willemsubmerged.wordpress.com/2008/03/08/prelude-for-the-scuttling-of-the-antilla-the-lost-wreck-of-the-troja/.
2. *A World War II airplane crashed west of the north point of Aruba in 1943.*
   Source: https://www.lago-colony.com/WORLD_WAR_II/THOSE_WHO_DIED/Deathlist1.pdf.
3. *The SS Invercorrie was a Venezuelan oil tanker that functioned between 1918 – 1938/1939 when it was subsequently dismantled and sunk in the area in front of Rodger's Beach.*
   Source: http://www.aukevisser.nl/uk/id266.htm.
   https://www.wrecksite.eu/wreck.aspx?281775.
4. *A cargo ship named Lady Patricia was built in 1947 and wrecked in 1954 off the coast of the Californian Lighthouse.*
   Source: https://www.wrecksite.eu/wreck.aspx?112950.
   https://www.wrecksite.eu/chartDetails.aspx?1158.
5. *A pier was built in 1927 to function as the Shell oil terminal pier located at Eagle Beach/Punta Brabo where tankers could dock.*
   Source: Dijkhoff, 2021.

Figure 22. Historical map of Aruba portraying documented potential underwater archaeological resources or the locations thereof. However, it must be noted that these ships or archaeological remnants thereof have yet to be found. Source: Internet Archive, BNA-DIG-MAPA-PANARUBAN-1940. URL: https://archive.org/details/BNA-DIG-MAPA-PANARUBAN-1940.

Uknown Industrial period underwater archaeological resources

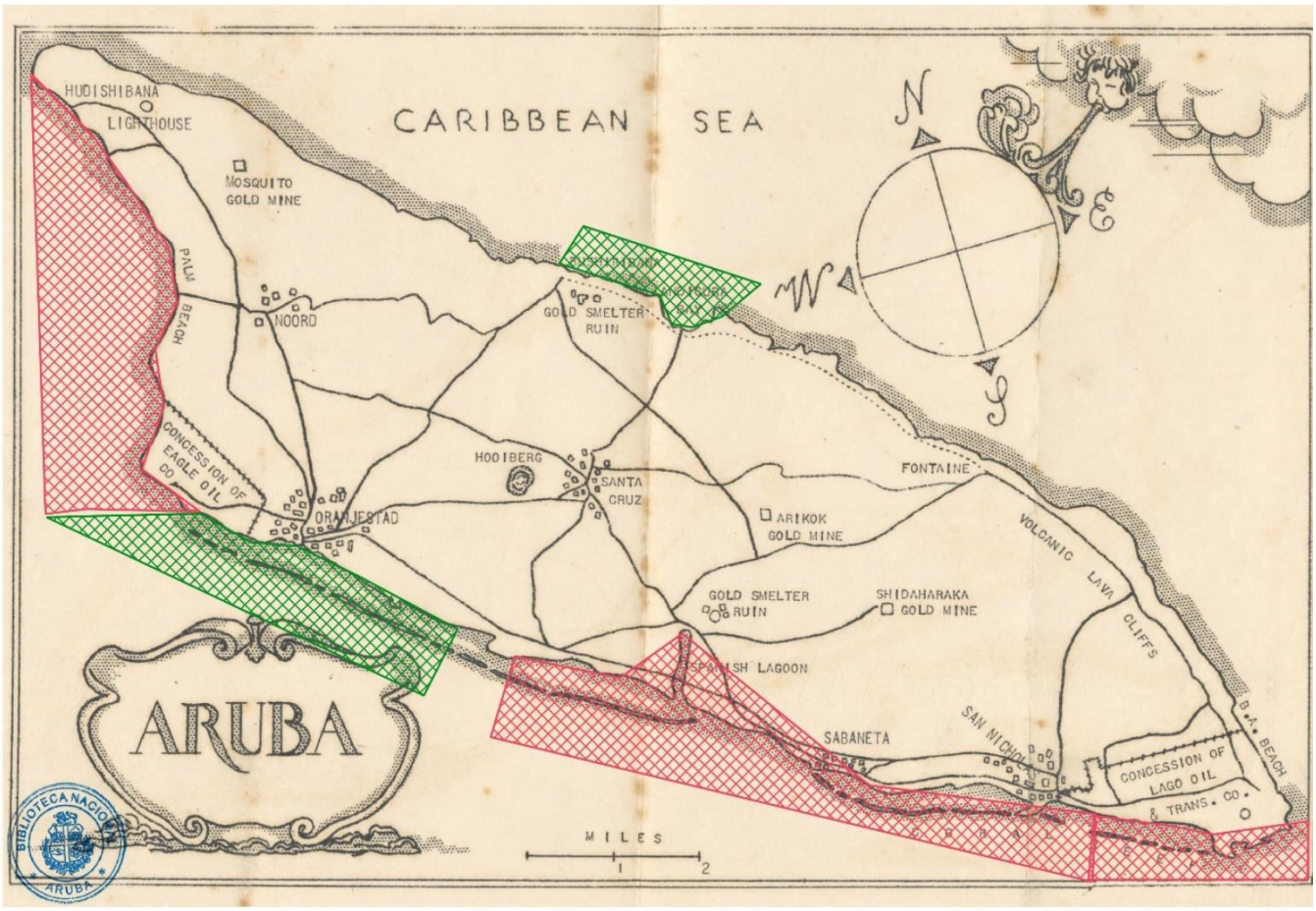


Figure 23. Historical map of Aruba portraying the high and low suspected locations where possibly unknown (potential) underwater archaeological resources dating back to the Industrial period are present. Map created by Gendra Lacle.

3.3 Future underwater archaeological resources

In addition to the known and unknown (potential) underwater archaeological resources present, Aruba has a total of fifteen future underwater archaeological resources all dating back to the Industrial and Modern period, namely between 1976 to 2015 (see attachment 1), and are all situated on the leeward side of the island (see table 4 and figure 24). Future underwater archaeological resources entail the known underwater archaeological resources that are physically present in situ but have been submerged for less than 50 years (Dijkhoff *et al*., 2012), and that are valued by the communities of Aruba. The future underwater archaeological resources are twelve shipwrecks, four airplane wrecks, and household furniture (Physical files available at the National Archaeological Museum Aruba, Oranjestad, Aruba).

The above mentioned future underwater archaeological resources are valued to the communities of Aruba as they are used as dive and snorkel locations and play a role in the economic gain for the island through tourism and fishing activities. In addition, the ships and airplanes that were deliberately sunk in order to create artificial reefs portray the history of Aruba during the 20th century (see attachment 1). Despite the fact that when a vessel is deliberately sunk it is stripped from all its materials, these vessels still portray the history of Aruba through the exploitation of the coastlines by building restaurants on the water, the shipping industry, and the local ships and airplanes used.

Table 4. Overview of the locations and site types of the known underwater archaeological resources. Source: Dijkhoff, 2021.

Time period	**Location**	**Site type**
Industrial period	San Nicolaas	Shipwreck
Industrial/Modern period	Oranjestad	Shipwreck
	Barcadera	Shipwreck
Modern period	Barcadera	Shipwreck
	Renaissance and Barcadera	Shipwreck
	Palm beach/Malmok	Shipwreck
	Oranjestad	Shipwreck
	Malmok	Shipwreck
	Renaissance	Airplane
	Palm beach	Shipwreck
	De Palm island	Shipwreck, airplane, household materials
	Renaissance	Airplane
	Mangel Halto	Shipwreck
	Barcadera	Shipwreck
	Arashi	Airplane

Future underwater archaeological resources

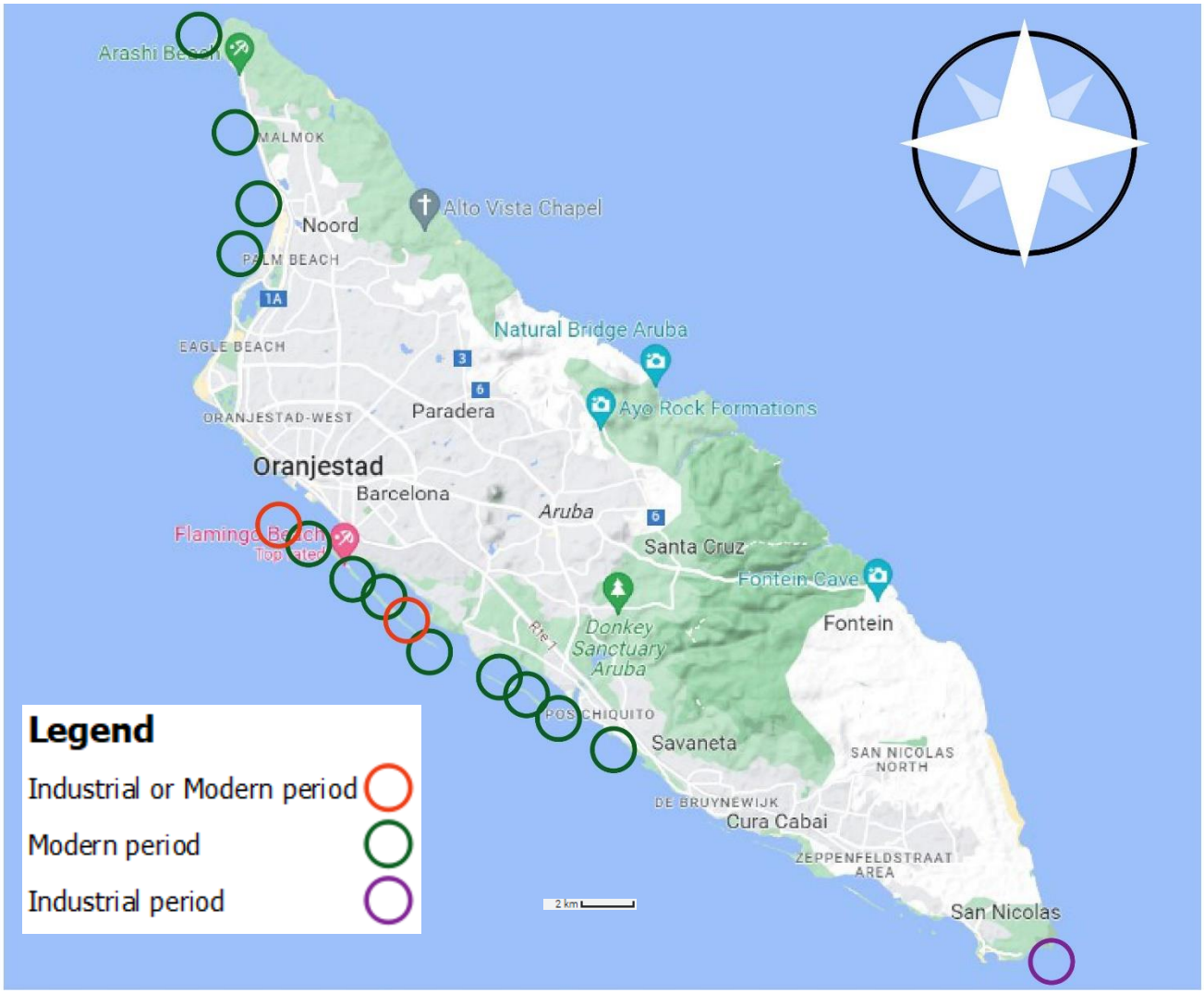


Figure 24. Topographic map of Aruba portraying the future underwater archaeological resources. Source: Digital files available at the National Archaeological Museum Aruba, Oranjestad, Aruba. Map created by Gendra Lacle.

3.4 Summary

The distribution of the underwater cultural heritage follows a certain pattern within the maritime and underwater landscape, namely the leeward side of the island was favored due to its calm waters and shallow sandbanks. Thus, what was made clear within this chapter is that the underwater archaeological resources, known, unknown, and future form clusters and layers within specific regions due to the fact that throughout the habitation history, different activities were conducted within the same regions. The cluster regions were namely the region between *Arashi* and Ea*gle beach*, *Oranjestad*, *Spaans Lagoen*, *Commandeursbaai*, *San Nicolaas*, and *Alto Vista*. During the precolonial period, clustering occurred in the northwest, more specifically the region between *Arashi* and *Eagle beach*, and the region between *Spaans Lagoen* and *Commandeursbaai* (see figure 25). *Commandeursbaai* was the central point during the Spanish period followed by the same regions as the precolonial period, namely the northwest region, and *Paardenbaai* and *Commandeursbaai* were the focused regions during the Dutch West India Company period. However, the windward side of the island was also used during this period, indicating an island wide usage. The Colonial period made use of the northwest and northeast side of the island through trade, gold mining and phosphate winning. Lastly, the Industrial period made use of the northwest region to anchor, *Paardenbaai* to trade and collect oil, and the southwest region to collect oil. What could still be present, namely the potential underwater archaeological resources, within the landscape could be an intermixed layer of different time periods together. Thus, it does not portray a chronological timespan due to the multitude of activities that took place in combination with continuous human activities and construction projects. This could have led to the displacement, looting, or it being ultimately completely lost due to human activities over time. What is known from the dredging documentation that occurred at *Paardenbaai*, it can be said that no archaeological materials are present up to a depth of eleven meters. This is expanded on in the chapter 4: Threats to Aruba's underwater archaeological heritage.

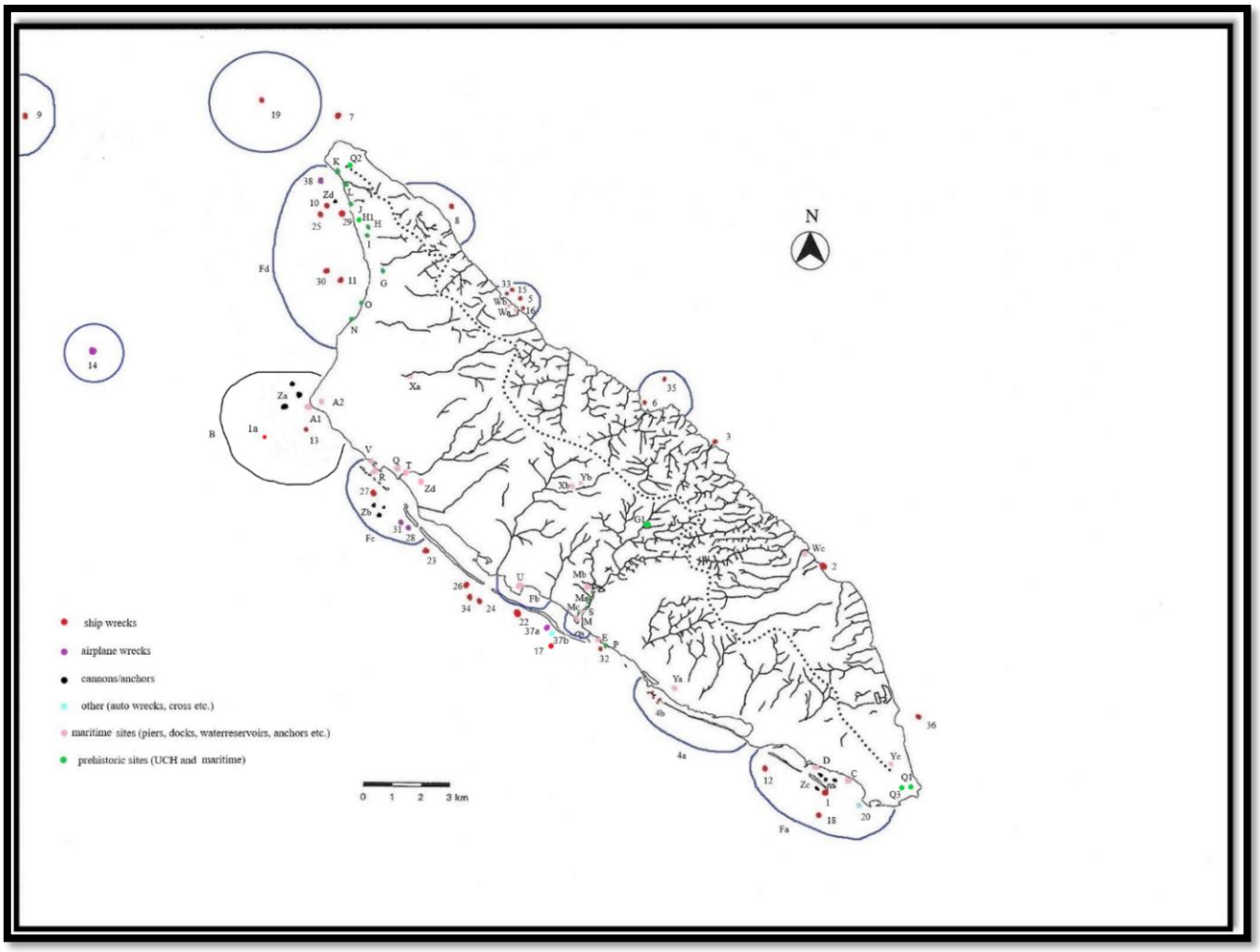


Figure 25. Overview of the underwater archaeological resources present in the surrounding waters of Aruba. Source: Dijkhoff, 2021.

Chapter 4 Threats to Aruba's underwater cultural heritage

As was explained in chapter 3 and attachment 1, Aruba's underwater cultural heritage was utilized for marine tourism development by using a majority of the known and future underwater archaeological resources as dive and snorkel sites. Therefore, Aruba's underwater cultural heritage falls within the economic activity framework of the island. However, a variety of natural and human threats are affecting the underwater archaeological resources. This chapter focused on the underwater and maritime landscape, and the threats to the underwater cultural heritage within the landscape. The underwater archaeological resources can have different causal threats, and said threats can lead to the destruction and loss of materials, information, and knowledge. Thus, assessing the threats to the underwater archaeological resources plays a prominent role in future management decisions. When assessing what is threatening the underwater cultural heritage, more often than not it is a combination of multiple processes that frequently influence each other. The following questions were explored within this chapter in connection with the threat factors, namely what was the real cause of the threat, is it local or regional, duration of the threat, what is it threatening, value of the site, and the condition of the materials. The above mentioned questions need to be addressed within this thesis report before the threats can be mitigated against. However, before delving into the threat factors affecting Aruba's underwater cultural heritage, it must be noted that this information was gathered from literature, photographs, oral history, and knowledge from divers, fishers, and archaeologists. Thus, this investigation conducted a non-intrusive maritime archaeological assessment of the threat factors.

The threats that can affect the underwater cultural heritage can occur on a micro or macro level. Threats to the underwater cultural heritage are often affected regionally, affecting a larger (macro) area within an environment. Threats on a micro level affects the underwater archaeological resource itself through natural and human processes. It is therefore important to analyze the environmental context of a site, as the surrounding conditions have a direct impact on the preservation status of the archaeological materials. It must be noted that the environmental contexts can differ per site leading to different levels of deterioration per individual site.

Thus, the quantity and quality of Aruba's underwater archaeological resources are in a constant state of change as they are influenced by natural and human factors (Manders, 2021, p. 3). It is crucial to understand the environment in which the underwater archaeological resources resides in, and the threats affecting them whether short or long term in order to create an accurate management plan. The major threat factors to Aruba's underwater archaeological resources are described below (see table 5). The threat factors found to be affecting the underwater archaeological resources within this thesis report portrays a lack of management and protection.

Table 5. Overview of the threat factors affecting Aruba's underwater archaeological resources.

		Threats
Natural threat factors	Mechanical threat factors	Climate change
		Currents
		Tsunami
		Hurricanes and tropical storms
	Biological threat factors	Cyanobacteria
		Anaerobic erosion bacteria
		Wood degrading bacteria
	Chemical threat factors	Metal corrosion
Human threat factors	Economic threat factors	Tourism
		Looting/ treasure hunting
		Fishing
		Dredging
	Socio-political threat factors	Coastal developments
		Lack of awareness
		Lack of knowledge
		Lack of laws and legislations

4.1 Marine environmental context

Aruba is 31 kilometers long and 10 kilometers wide, at its widest point, and is located in the most southern region of the Dutch Leeward islands within the Lesser Antilles (Mickleburgh, 2013, p. 42; Vermeij *et al*., 2020, p. 8). The island has a semi-arid tropical marine climate with a relatively equal temperatures year round (Colijn et al., 2019, p. 68). Tropical winds occurs more frequently and plays a role in the amount of rainfall. The amount of rainfall decreases from the southeast to the northwest due to the direction the wind blows (Vermeij et al., 2020, p. 8-9). Strong winds dominate the northeast side with a steady longshore current running along the southern coast with heavy surf conditions along the eastern and northeastern coasts (Eakin *et al*., 1993, p. 139). The leeward side of the island consist of a barrier reef ca. 366 meters from the shore extending along the southwestern coast in addition to *salinas*[5] and limestones on the northwest, southwest, and south side of the island. The coastal regions and inner land water systems are intertwined and influences one another especially during the wet, rainy, and hurricane season (Kelly and Hofman, 2019, p. 147-148; Ruiz, 2004, p. 11).

The marine environment of Aruba contains different ecosystems in which the underwater archaeological resources resides in. Figure 26, portrays the different ecosystems and marine habitats up to a depth of circa ten meters. Sandy beaches with intermixed habitats were prominent on the leeward coast while the entire windward side of the island has small less defined coral reefs to a larger degree in comparison to the leeward side. Different species of seagrass are present on the leeward side in varying densities, from sparse, moderate to dense clustered for a majority in the northwest region of the island. The underwater environment within the barrier reef of the leeward side consists of multiple complex soft bottom habitats where the region is covered in sparse to dense seagrass (Vermeij *et al*., 2020. P. 17-18).

When looking at the island development plan (ROP), the entire coastline of Aruba is dividied into different designated areas, which in turn are linked to the threat factors affecting the underwater archaeological resources. The coastlines are designated as a harbor front, economic areas, addition to the marine park, nature and landscape areas, sandy beaches, and touristic areas. The surrounding waters that are not part of the marine park are considered coastal waters (ROP Aruba, 2019). The regions where these designated areas are situated in and the status thereof are shown in appendix 4.

[5] A salina is a salt lake or salt marsh.

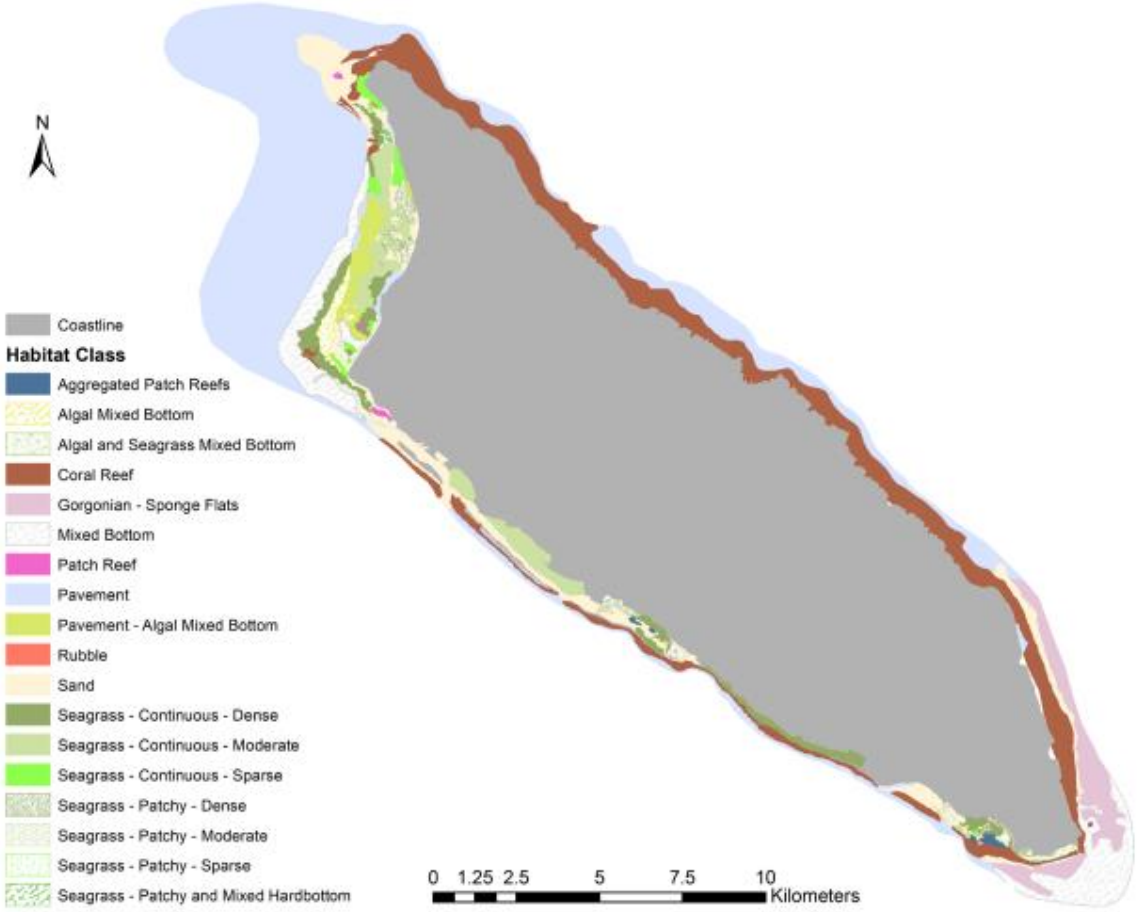


Figure 26. Map of Aruba portraying the marine ecosystems within the underwater environment. Source: Vermeij et al., 2020, p. 17.

4.2 Natural threat factors

Natural threat factors discussed within this thesis report include mechanical (physical), biological, and chemical degradation. Natural threats can be split into two deterioration processes, namely in the seabed and above in open water. The threat factors affecting the underwater archaeological resources are therefore dependent on whether the site is situated on the sea floor exposed to the sea water and oxygen or (partially) buried in the sea floor in an anoxic environment. Sites situated on the sea floor are more often subjected to mechanical and biological deterioration processes, especially the degeneration of organic materials. Chemical processes in turn play a role in the corrosion process of iron and other metals. However, the different natural threat factors interact and influence one another. In addition, natural processes, namely mechanical, biological, and chemical are continuously occurring threats. Therefore, by understanding the deterioration processes of the underwater archaeological resources, insight can be gathered on how to best preserve them in situ (Manders, 2021, p. 3).

4.2.1 Mechanical threat factors

When an underwater archaeological site sinks or becomes submerged, it comes to rest on or in the seafloor. What follows are post-depositional processes that form the marine environment and site. A marine environment can be very active and therefore underwater archaeological resources located within can be vulnerable to physical processes. Physical processes, namely scour, erosion, and sediment movement can cause underwater archaeological resources to become less stable or it can expose the site above the seafloor. This in turn leads to fast and extensive loss of archaeological materials. Erosion can have positive or negative effects, namely it may lead to an underwater archaeological resource being discovered. However, when a site is uncovered or remains under the sea floor, it can lead to rapid degradation of the materials. Thus, mechanical threat factors in the form of physical processes entails underwater archaeological resources being washed away or torn apart leading to the displacement, erosion, or destruction of sites (Manders, 2017, p. 68; Ridwan, 2015, p. 19). Mechanical threat factors are hurricanes, tsunamis, tropical storms, and regions with (strong) currents and tidal movements. Tropical hurricanes and storms, if severe enough, can impact/damage the structure, create debris, or even relocate parts or entire frameworks of living and artificial reefs (underwater archaeological resources). Only environmental threats to the artificial reefs are analyzed within this thesis report. The results of tsunami and tropical storms are erosion and deposition of coral debris (Scheffers *et al*., 2009, p. 69). The level of damage caused by environmental factors vary based on the severity, the periodicity, and the wave height and velocity (Scheffers et al., 2009, p. 78).

Tsunami

Tsunami and hurricane waves are hydrodynamically different and thus impacts the underwater archaeological resources differently. Tsunami and tropical storms are natural events capable of destroying or relocating materials and frameworks, and can even deposit materials on land (Scheffers *et al*., 2009, p. 70). A tsunami is categorized as a few large high velocity waves that lasts for a longer period of time. Tsunamis causes disruption in the sediment underwater, on the shorelines, and beaches. The sediment are then transported and distributed over a large region (Scheffers *et al*., 2009, p. 70). Evidence for three paleo tsunami events were recorded within the landscape of Aruba which occurred during the Younger Holocene at 1500 BC, 450 AD, and 1450 – 1550 AD. The tsunami impacted the island from a northeastern direction, with evidence of the most tsunami deposits, namely boulders, ramparts and ridges, being located at the southeast coast of *Sero Colorado*, the northeast and east coast extending from *Arashi beach* to natural bridge and on the coast of *Dos Playa* (see figure 27).

The tsunami events could have therefore removed or warped the archaeological evidence of precolonial sites. The waves from a tsunami can relocate or completely remove sediments and archaeological materials to other land regions or to the sea floor. The precolonial sites were vulnerable to damage or removal as the sites were situated on the shallow layer of sediment on the limestone terraces (Scheffers, 2002, p. 26; Scheffers, 2004, p. 167; Scheffers *et al*., 2009, p. 83-84). After the first three tsunami events during the precolonial period, no written or oral sources describing a tsunami event were recorded, spanning a time span of 350 – 400 years indicating no tsunami event since the Spaniards found Aruba (Scheffers, 2002, p. 35).

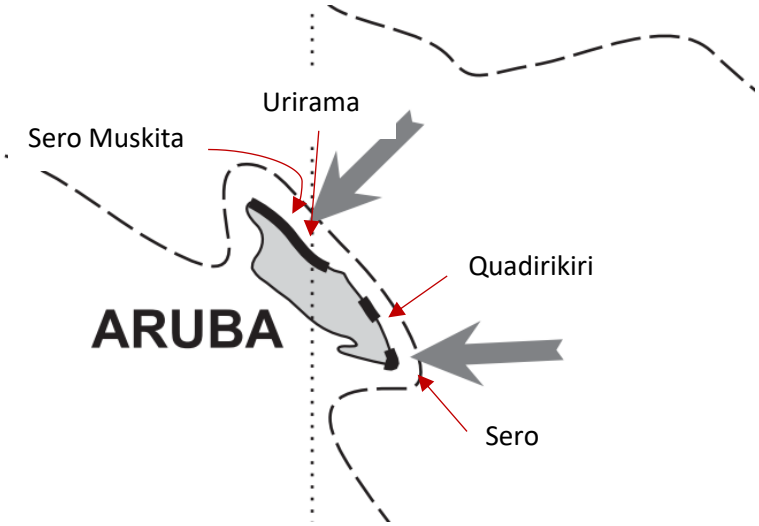


Figure 27. Location of most significant tsunami deposits, namely boulders, ramparts, and ridges on Aruba. Source: Scheffers, 2004, p. 167.

The impact to the underwater archaeological resources were analyzed and speculated based on the 2nd and 3rd tsunami events as the 1st tsunami took place around 1500 BC which was also around the same time the first indigenous people began migrating to the island. Given the time frame and location where the tsunamis hit the island, damage to the underwater archaeological resources would have been minimal as far as quantity is concerned. However, the damage to the Archaic period sites located on the windward side, during the 450 AD and 1450 – 1550 AD tsunami events, would have been extensive as the sites were situated on the most upper layer of the limestone terraces. When combining the locations where tsunami deposits were found with the locations of Archaic period sites found and documented, correlations could be found at the following sites, namely *Sero Muskita*, *Urirama*, *Quadirikiri*, and *Sero Colorado* (see figure 27). It could therefore be possible that this region contained more Archaic period (temporary) activity sites which were subsequently swept away during the two tsunami events and were lost at sea.

Carbon dating from Sero Colorado, Urirama, and Quadirikiri portrays dates between circa 20 – 670 AD, making them susceptible to the second and last tsunami event (Kelly and Hofman, 2019).

Hurricanes and tropical storms

Hurricanes are a more commonly occurring natural disaster than tsunamis. In the last 100 years, circa 1000 tropical storms and 200 hurricanes passed through the Intra-Americas Seas region (Scheffers *et al*., 2009, p. 76). However, Aruba is situated in the southern fringe of the hurricane belt. This signifies that tropical storms or hurricanes rarely pass within the 100 nm zone of Aruba, meaning that tropical storms or hurricanes rarely directly affect Aruba (see figure 28) (Scheffers, 2004, p. 164). Figure 29 portrays the few hurricanes that passed within 100 nm from Aruba between 1605 – 1998 (Scheffers, 2002, p. 32).

Hurricanes usually impact the island from the northern coast as they tend to have more waves and wind. Aruba gets hit approximately once a year by the effects of hurricanes. However, most of these hurricanes do not make contact with the island and the extent of impact are increased wind and rain (AZ-Animals: https://a-z-animals.com/blog/when-is-hurricane-season-in-aruba-peak-timing-and-earliest-hurricane-on-record/#:~:text=Aruba%20gets%20a%20hurricane%20around,as%20a%20Category%201%20hurricane). Based on historical colonial reports and newspaper articles, the following historical hurricane events occurred in the vicinity of Aruba, namely in 1605, 1784, 1831, 1877, 1886, and 1892 (Hurricane City: https://hurricanecity.com/city/abcislands.htm). Newspaper documented the historical hurricane event that occurred in 1877 named *Tecla* which caused damage to the ABC islands (Aruba, Bonaire, and Curaçao) and the Peninsula of Venezuela (Amigoe, 1977).

Hurricane *Tecla* was a category two causing rough waters on the coastlines of the ABC-islands (Diaro, 2020). Correspondence between Aruba and Curaçao documented a hurricane that passed in the vicinity in 1886 which had a significant impact on Aruba. A total of three ships lost their anchors and subsequently stranded on the beach, in addition to smaller vessels being pushed on the coast or capsizing and some ended up sinking. The hurricane of 1886 caused the ship Hero to sink (Dijkhoff *et al.,* 2012). Aside from the historic hurricane events mentioned above, recent hurricanes are also known to have passed and impacted the island, between the 20th and 21st centuries, namely hurricane *Hazel* in 1954/55, *Lenny* in 1999, *Ivan* in 2004, *Emily* in 2005, *Felix* in 2007, *Matthew* in 2016, and *Nicole* in 2022. Hurricane *Hazel* caused flooding on the leeward side of the island. Hurricane *Lenny* had wind speeds over 160 km/h and passed 250 – 500 km north of Aruba causing heavy surf conditions along the southwestern coastlines.

The waves varied in size ranging between 3 – 6 meters, and caused an up spit of debris indicating that the sediment on the seafloor was disrupted to a certain degree (Scheffers, 2004, p. 169-170; Scheffers, 2002, p. 32). In addition, hurricane *Lenny* was strong enough to move entire frameworks situated on the sea floor. The wreckage of *Baboo* was sunk in the 1990's but was pushed to shallow waters during hurricane *Lenny* (Dijkhoff, 2021). The eye of hurricane *Ivan* passed Aruba at a distance of 130 kilometers north in 2004. Winds did not reach the island of Aruba but large waves did make enough impact to flood and damage several coastal locations and constructions. One year later, hurricane *Emily* passed Aruba at a distance of 175 kilometers impacting the northside of the island. Hurricane *Felix* followed in 2007, causing heavy rains and rough sea conditions (Meteorological Department Curaçao, 2013, p. 18). In 2016, hurricane *Matthew* caused minor damage through strong winds and flooding from increased rain, and in 2022 more extensive damage was done by hurricane *Nicole* as this hurricane made landfall as a category 1 reaching winds between 74 – 95 miles per hour. The north and northwestern region of Aruba was impacted the most by hurricane activities with strong winds and large waves hitting the island. Coastal erosion caused by the hurricane activities directly impacted the known precolonial sites, as they are situated at *Arashi*, *Malmok*, and *Palm Beach*. The rough seas and winds causes debris from the ocean to wash up on the shorelines and materials from the shorelines to wash away into the ocean. The precolonial settlements situated on the northwest coastline are continuously being eroded through normal wind and tidal movements. However, hurricane events accelerate the erosion process. Rough or extreme tidal movements could have dislodged materials from the known shipwrecks the Californian, SS Pedernales and SS Arkansas, and SS Antilla, and future ship-, and airplane wrecks. Therefore removing the materials from their original archaeological context. In addition, the entire northwest region of the island was extensively used during the precolonial period where the indigenous people settled and made use of the marine and underwater landscape, and this region was used as anchorage during the Dutch West India Company, Colonial and Industrial period. Therefore, potential underwater archaeological materials present could have been displaced, namely anchors and ship materials.

Tropical storms produce waves that flood the land for hours on end and the waves vary in sizes and strength. Tropical storms cause gradual and prolonged damage to the maritime and underwater environment. The waves cause damage to the beaches and dunes through erosion and sediment exchange between the shore and the sea floor with it being relocated to the sea floor in close proximity to the shore or on the shore creating a ridge.

The time lapse between tropical storms affecting the island determines the extent of weakening that occurred to the framework which in turn can lead to significant damage occurring during following storms (Scheffers *et al*., 2009, p. 70-71, 78). Recent documented tropical storms were namely tropical storms *Joan* 1988, *Bret* 1993, *Cesar* 1996,*Omar* 2008, and *Tomas* in 2010. Tropical storm *Joan* passed south of Aruba causing rough seas to continuously hit the exposed harbors and beach facilities, in addition to causing widespread flooding over the islands due to excessive rain lasting several days (Meteorological Department Curaçao, 2013, p. 17). When looking at the region tropical storm *Joan* hit, it could have caused damage to the harbors and beaches of *San Nicolaas*. The rough seas and flooding from the excessive rain causes rougher tidal movements which in turn can dislodge and be either swept away to sea or onto the shore. Tropical storm *Joan* could have also cause damage for the future underwater archaeological resource at *San Nicolaas*, namely the shipwreck Colombo. However, little is known about this shipwreck, thus the extent of damage tropical storms caused needs to be further researched. The two following tropical storms, namely *Bret* in 1993 and *Cesar* in 1996 caused minimal impact and damage to the southside of the island where they passed. Tropical storms *Omar* on the other hand had large and strong wind fields. Tropical storm *Omar* hit the southwest island with strong winds in turn creating strong waves hitting the coastlines of the west and south shores in 2008. The waves and winds caused significant damage to smaller vessels situated in this region in addition to coastal facilities such as harbors and causing significant coastal erosion. Precolonial settlements are most susceptible to coastal erosions as they are situated on the upper layer of the limestone terraces. In addition, the west side of the island was extensively used during the Historic period for trading, war activities, and daily activities. The rough seas can dislodge, replace, destroy, or relocate archaeological materials on and in the seabed. Tropical storm *Tomas* passed the ABC islands in 2010, however the damage to Aruba was minimal (Meteorological Department Curaçao, 2013, p. 17-18). Thus, the archaeological materials present at the precolonial sites at *Mangel Halto*, and the harbors of *Spaans Lagoen* and *Commandeursbaai* were susceptible to being displaced or destroyed due to rough waters, in addition to the future underwater archaeological resources and possible underwater archaeological materials situated at the west and southwest side of the island. However, relatively small waves from the normal current making contact with the shoreline can cause also cause erosion. This is a continuous and long-term threat to the precolonial sites.

As was mentioned in chapter 3, all the known precolonial sites from the Archaic (1500 BC – 900/1000 AD), and the Ceramic period (900/1000 AD – 1515 AD) were identified as (temporary) activity sites that are now (partially) submerged due to mechanical threat factors, namely different types of erosion. Aside from the natural disasters that can occur, climatic factors can create regions with strong currents and tidal movements that can in turn provide a hostile environment for the (un)known underwater archaeological resources. The entire windward side of the island features a cliffside coastlines with wind and rough waters which is not a beneficial environment for the preservation of underwater archaeological resources. In addition, climate change can cause a change in the sea level in the future which in turn can cause the destruction of coastal precolonial settlements, historic harbors and constructions (Symister and Dijkhoff, 2022, p. 40). However, normal coastline water movements can also cause continuous coastal erosion over time.

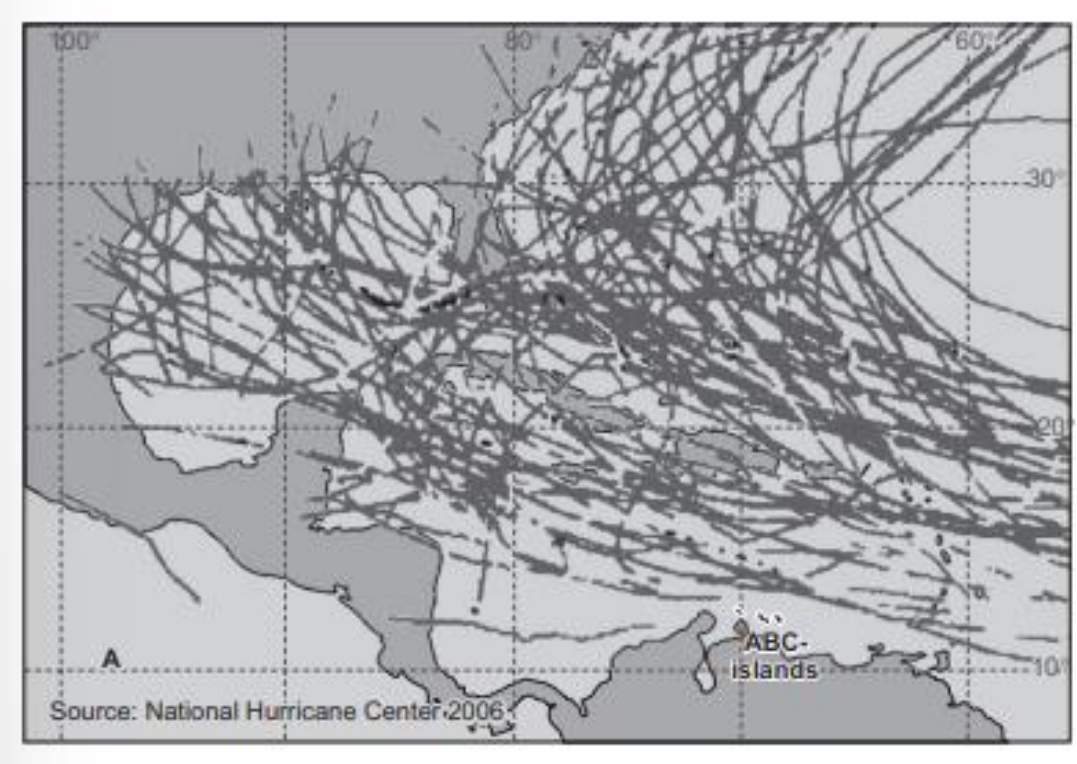


Figure 28. Hurricane tracks in the Intra-Americas Seas region between 1850 - 2005. Source: Scheffers et al., 2009, p. 76.

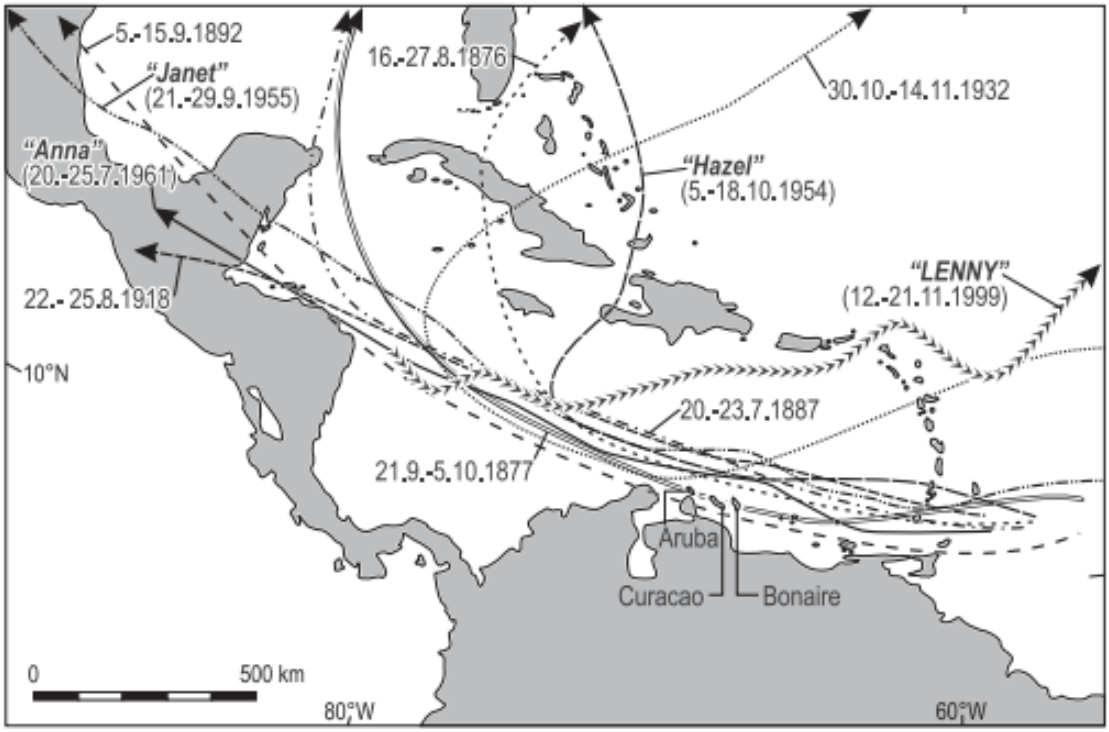


Figure 29. Portrayal of the few hurricanes that passed within the 100 nm zone from Aruba between 1605 - 1998. Source: Scheffers, 2002, p. 32.

4.2.2. Biological threat factors

The effects biological threat factors can have on the underwater archaeological resources vary depending on the material. The extent of the biological deterioration is primarily dependent on the levels of oxygen present. A distinction can therefore be made between the deterioration processes that occur below and above the sea floor. The levels of oxygen present below the sea floor are very low or completely absent. However, sea organisms can burrow into the sea floor through bioturbation and introduce oxygen below the sea floor. When an underwater archaeological resource is directly exposed to seawater while it is situated on a thick layer of sediment, it can be exposed to an aerobic environment and therefore become vulnerable to biological and chemical deterioration. Biological deterioration of underwater archaeological resources can occur due to marine borers, fungi, and bacteria (Manders, 2017, p. 83-84; Ridwan, 2015, p. 19). When an underwater archaeological resource sinks, it will become quickly colonized by a variety of marine animals. Therefore, the environment where the underwater archaeological resources resides are rich in oxygen and are susceptible to the biological deterioration processes.

Recent research conducted by the CARMABI foundation situated in Curaçao (Vermeij *et al*., 2020) revealed that sewage water is being released into the coastal waters of Aruba at *Savaneta*, *Pos Chikito*, *Sero Colorado*, *Zeewijk*, *Bubali*, and *Parkietenbos*, with high accumulations present along the northwest region from *Arashi* to *Barcadera*, and at *Savaneta* (Vermeij *et al*., 2020, p. 33). The introduction of sewage water into the ocean also introduces new organic matter which are food sources for bacteria. The increase of the bacteria activity turns the organic matter into inorganic nutrients which depletes the oxygen within the environment (Gast et al., 1999, p. 523). This in turn created an anoxic environment where cyanobacteria and algae began dominating the benthic community (Vermeij *et al*., 2020, p. 33). An anoxic environment is defined as an aquatic environment decreased of oxygen causing aerobic organism activity to stop (Demaison and Moore, 1980). Anoxic sediments were observed along the northwestern region creating a beneficial environment for cyanobacteria and algae (Vermeij *et al*., 2020, p. 33). Cyanobacteria are aquatic blue-green algae that thrive in warmer and saline environments (Whitton and Potts, 2012). Cyanobacteria bores into calcareous stones and organogenic structures, namely corals, shells, and underwater plants. The cyanobacteria then takes residence in the bored cavities and tunnels, and largely effects stone artifacts (Perasso et al., 2022, p. 4). When looking at the locations of the cyanobacteria clusters and the locations of the underwater archaeological resources (known, unknown, future), stone tools used during the precolonial period could be susceptible to this bioerosion. More specifically, a high suspected cyanobacteria environment is present at *Arashi* and *Paardenbaai*. Archaic period temporary settlements were found at *Arashi* and it is suspected that *Paardenbaai* was used during the Ceramic period and this was built upon with the finding of precolonial urns during construction work. However, due to the extensive dredging and construction that occurred at *Paardenbaai* (see chapter 4.3), a low amount of archaeological materials from the precolonial period could be present. In regards to the Historic period, stone ballasts were located at *Commandeursbaai* which could be effected by cyanobacteria.

Historical and archaeological wooden objects preserve for the most part better in wet environments. However, if the environment is anoxic or anaerobic, this creates a beneficial habitat for anaerobic erosion bacteria which slowly degrade waterlogged wood, leading to wood materials having water-filled cavities. Wood materials with water-filled cavities cause the structures to become porous and fragile which can break apart during the salvage and deterioration processes (Colombini *et al*., 2009, p. 61). From the material analysis conducted within this thesis report, two out of the 45 finds were wood materials. The wood artefacts were in good condition, indicating that the materials did not undergo (or very little) biological deterioration (see figures 30 and 31). However, the environmental context where the wood resided in before it was lifted is unknown.

Nevertheless, as was mentioned above, sewage water are being distributed within the sea which in turn is causing specific regions around Aruba to become anoxic that in turn can create an environment where anaerobic erosion bacteria lives. This makes the wood materials still present within the known shipwrecks, SS Pedernales, SS Arkansas, SS Antilla and the harbor *Commandeursbaai*, namely ship equipment, inventory, personal items, cargo or trade, and remains of harbor materials susceptible to slow degradation of the wood materials through anaerobic erosion bacteria. In addition, if wood are present at the following future underwater cultural heritage sites, namely Bali barge wreck, Topaz, Debbie II, Tugboat shipwreck, Baboo, Douglas DC-3 airplane, Star Gerren/Santa Maria, Airplane S-11 and Lockheed Lodestar, they are therefore undergoing slow biological deterioration. However, if or what the wood materials present at these shipwrecks are and the state of preservation are unknown and needs to be further researched. An anaerobic environment puts future underwater archaeological resources made from wood materials at risk for future wood deterioration through bacteria erosion.

When combining the locations where potential underwater archaeological resources may be located and which materials can be expected within the anoxic environments, the following regions may contain wood materials that are undergoing slow anaerobic erosion bacteria deterioration namely, ship and fishing material remnants at *Commandeursbaai* during the Spanish period, ship, cargo, and fishing material remnants dating back to the Dutch West India Company period at the northwestern region and *Commandeursbaai*, remnants of war activities, construction, ship and fishing materials located in the northwestern region from the Colonial period, and lastly industrial, constriction, ship, and fishing materials in the northwestern and southwestern region of the island (see figure 32).

Figure 30. A wooden dagger found and lifted from the shipwreck SS Pedernales. Photograph by Gendra Laclé.

Figure 31. Possible binoculars found and lifted from the shipwreck SS Pedernales. Photograph by Gendra Lacle.

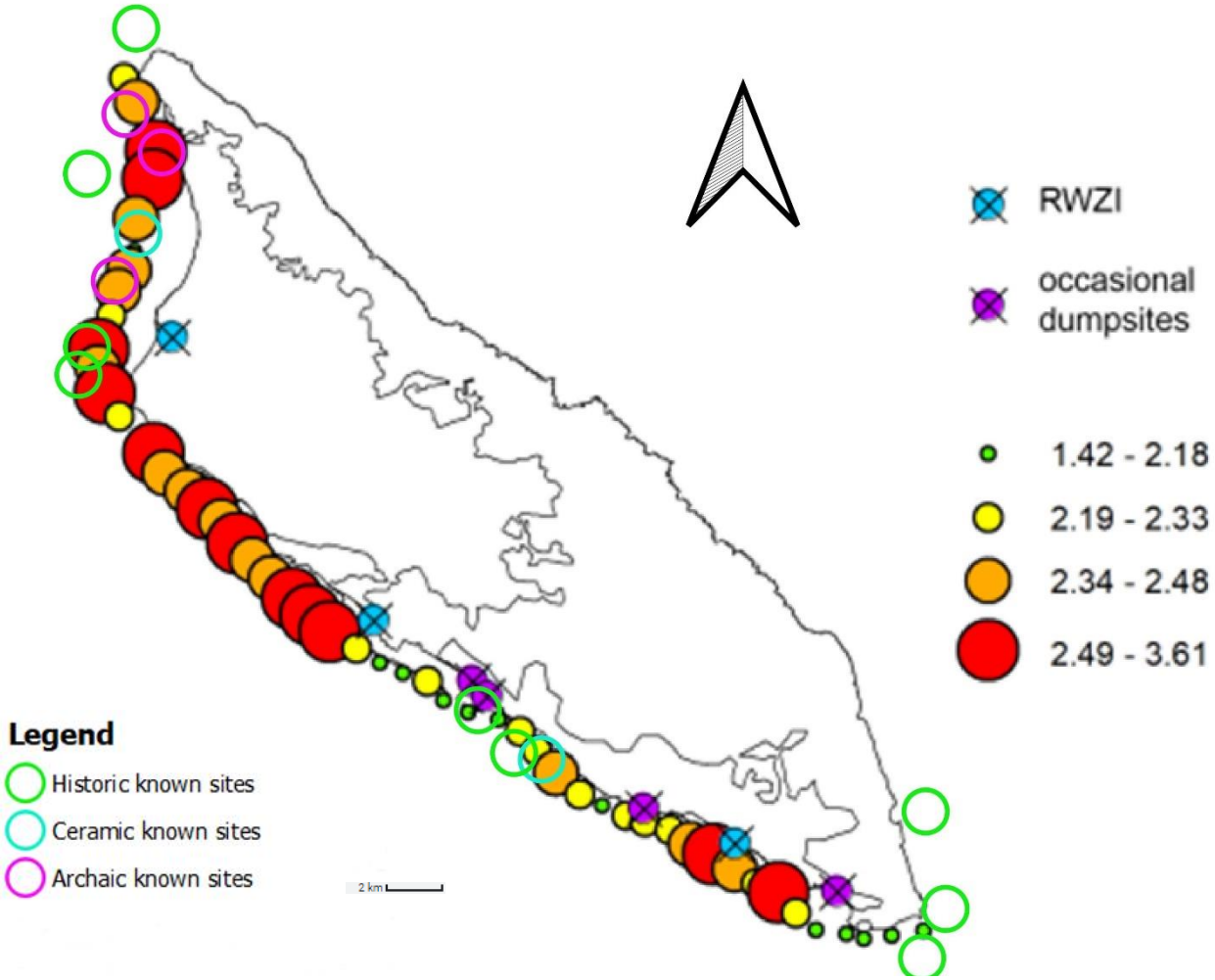


Figure 7. Map of Aruba portraying the regions with high accumulations of sewage water creating anaerobic environments with the locations of the known and future underwater archaeological resources. The red, orange, yellow, and green dots on the map are indications of the distribution levels of sewage water within the environment, with red being highest and green the lowest. The blue dots are the locations of the sewage treatments plants and the purple are categorized as trash dump sites. Source: Vermeij et al., 2020, p. 34. Map created by Gendra Lacle.

However, aside from the anoxic environments distributed within the underwater landscape, aerobic environments are also present. The wood materials could therefore be undergoing microbial and marine borer deterioration. When wood is situated in an aquatic environment, it is subjected to wood degrading bacteria and wood eating micro borers (Kim and Singh, 2000). Wood materials are susceptible to wood borers mollusks and crustaceans, which causes the wood to deteriorate. Thus, wood-boring organisms, or shipworms are considered a big threat to the wooden underwater archaeological resources (Sivrikaya, 2019). When looking at the history of maritime construction, wood was one of the main materials used due to its wide spread availability. Therefore, it was used for a long time in the built of ships, harbors, and fishing materials (Borges, 2014). This was no exception to the ships that came to Aruba during the 16th to 18th centuries, or the harbor construction that began during the 19th and 20th centuries, and the fishing materials used throughout time. All the wooden artefacts present at the known, unknown, and future underwater archaeological sites were and are therefore susceptible to micro-borers. The underwater archaeological sites that are now situated within anoxic environments, namely the known shipwrecks, SS Pedernales, SS Arkansas, SS Antilla and the harbor *Commandeursbaai*, namely ship equipment, inventory, personal items, cargo or trade, and remains of harbor material, were situated within an aerobic environment before the introduction of the sewage water, and the wooden artefacts situated on the seabed underwent micro-borer deterioration. However, the extent and which biological organisms affecting the underwater archaeological resources needs to be further researched.

4.2.3 Chemical threat factors

Chemical threat factors entail the degradation process in which iron and other metal materials corrode, especially when the material is located in an oxygen rich environment. The less oxygen present within the marine environment, the less corrosion that occurs (Ridwan, 2015, p. 19). Corrosion and chemical deterioration processes are naturally occurring threat factors. However, the large and continuously increasing amount of visitors to the underwater archaeological resources and sites (see chapter 4.3. human threat factors) can play a role in the acceleration of chemical processes. The concentration of oxygen released by divers can turn into air pockets that become trapped in the metal materials. The introduction of (more) oxygen within the marine environment will increase the level of corrosion and thus subsequent speed up the chemical deterioration processes (Ridwan *et al*., 2014, p. 889). The degree of corrosion of the metal underwater archaeological resources were analyzed and speculated based on photographs.

Of the total seventeen known underwater archaeological resources, nine were made or contained metal materials all dating back to the Historic and Modern period, namely from the 17th century onwards up until 1963, with six being shipwrecks and one religious iron cross (see attachment 1). In addition, and as was mentioned within this thesis report, a small material analysis was conducted for this thesis on archaeological materials lifted from the shipwreck SS Pedernales. Out of the 45 finds lifted from the SS Pedernales, 39 were metal objects. Due to the fact that the metal objects were analyzed macroscopically, the exact compilation of metal alloys of each metal object cannot be definitively determined. However, two metal types were identified, namely iron and copper. Thus the metal objects were documented as iron, iron/copper mix, or copper mix (see appendix 5). From the SS Pedernales assemblage, four metal objects were iron, four iron mixes, thirteen copper/iron mixes, and eighteen copper mixes. The metal objects containing iron portrayed varying degrees of corrosion (see attachment 2). However, the extent of damage cannot be determined without future X-radiography research. Most historic ships contains iron, from the nails and bolts, ship equipment, rigging elements, chains, anchors, iron cannons, tools used on the ship including the ship itself. When a ship sinks, the iron objects undergo severe chemical degradation and the object eventually becomes covered in a bulky corrosion. Iron objects within a maritime archaeological context can be found as what is called concretions, which is when an object is completely covered by a thick mass of corrosion that can also incorporate sediment, shells, and other objects in the vicinity. Extreme corrosion of iron can lead to the original object migrating completely into the corrosion layer, and thus the iron deteriorates completely only leaving the concretion that retains the shape of the object (Wreck of the Week: https://thewreckoftheweek.com/tag/concretion/). Within this assemblage, eleven iron (copper) mix objects portray concretions to varying degrees (see figures 33-35) (see attachment 2). The iron objects portrayed chemical deterioration in the form of rust (see figure 35). Metal objects containing copper are more resistant to corrosion by the formation of a protective surface film. The surface form when the copper object is submerged in seawater due to air and seawater reacting together (Copper Development Association, 2012). This was also the case with the copper mix metal objects found within the SS Pedernales assemblage, as they only portray light corrosion (see attachment 2).

Out of the six shipwrecks, four could be speculated to be made out of steel as they were oil tankers and cargo ships from the 20th century. Steel is made out of different elements, the two main ones are iron and carbon, which undergoes chemical processes when in contact with seawater (MacLeod, 2016, p. 2). Steel structures are ideal for the growth of coral reefs organisms, and this can be seen on the fact that the known six shipwrecks are now artificial reefs within the marine environment.

Marine concretions are present on all six shipwrecks in varying degrees (see figures 36 – 40). Steel and iron objects situated underwater are attractive to marine organisms as they provide iron that is beneficial for their growth. The thickness of the marine concretion is influenced by the amount of phosphorus present within the iron alloy what the ship is made out of (MacLeod, 2016, p. 2). However, the extent and thickness of the marine concretions on the known shipwrecks is unknown as no in field measurement research were conducted. The ship structures are therefore susceptible to a slow chemical corrosion process as varying degrees of marine concretions are present on the exterior of the shipwrecks. In addition, the metal corrosion of the underwater archaeological sites situated within the regions being depleted of oxygen are slowed down further. However, when mechanical factors occur, namely tropical storms, hurricanes, and tsunamis that can remove the concretion, the corrosion rate accelerates rapidly as the seawater and subsequent oxygen now has direct influence on the archaeological materials. Additionally, human activities and interference can also cause the removing of concretions through mooring and anchoring (MacLeod, 2016, p. 5). Thus, the tropical storms and hurricanes hitting the northwester to southwestern side of the island can affect the artificial reefs on the known shipwrecks and future ship-, and airplane wrecks. In addition, human interference also affecting the concretions, namely diving or fishing activities can dislodge the organisms situated on the shipwrecks.

Figure 33. Metal object portraying how it was completely covered by concretion. Photograph by Gendra Laclé.

Figure 34. Anchor lifted from the SS Pedernales portraying concretion that covered almost the entire object itself. Photograph by Gendra Laclé.

Figure 35. Iron key affected by corrosion in the form of rust due to being underwater. Photograph by Gendra Laclé.

Figure 36. English steamship The Californian situated in front of the dunes at Hudishibana/Cudarebe. Source: Dijkhoff, 2021.

Figure 37. German cargo ship SS Antilla located on the seafloor at Malmok, Aruba. Source: http://scubadivers-aruba.com/projects/1-antilla-wreck.

Figure 38. British oil tanker SS Pedernales located on the seafloor at Palm Beach in front of Marriot Lighthouse Tower. Source: http://scubadivers-aruba.com/projects/3-pedernalis-wreck

Figure 39. Propellor of the British oil tanker SS Oranjestad. Photo taken by the SS Oranjestad Memorial Committee.

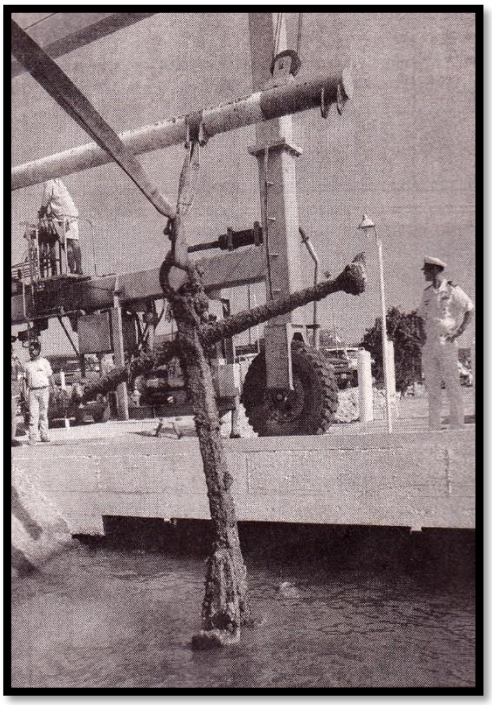


Figure 40. Picture of an anchor belonging to the SS Arkansas being lifted from the sea. Source: Dijkhoff, 2021.

4.3 Human threat factors

Human threat factors can cause different levels of damage to the underwater cultural heritage. Human activity can affect the underwater cultural heritage directly or indirectly. The human threat factors discussed within this thesis report pertains to the threats on Aruba's underwater cultural heritage that fall under socio-political, economic, physical, and managerial threat factors.

Economic threat factors

The Aruban economy relies significantly on the maritime and underwater environment with its associated wildlife in the form of tourism, fishing, and trading. The maritime and underwater environment attracts tourists to the island. The number of tourists that visit the island annually was less than one thousand in the early 1950's and is now over 1.5 million present day, and will most likely continue to grow in the future (Luksenburg and Parsons, 2014, p. 136). With an increase of tourism, an expansion can occur regarding looting and treasure hunting. Treasure hunting or looting aims to find valuable treasures. It is usually triggered by the assumed economic value of the archaeological finds. However, it is not always clear whether it was treasure hunting, looting, or souvenir hunting. Looting and treasure hunting can be problematic in regard to the context and site as when the artifacts are removed, the real context is often forgotten or lost. The story of the site/ underwater archaeological resources loses its scientific basis making the information gained less and untrustworthy, in addition to the sites themselves losing part of their story making it more difficult for researchers and causing damage to the sites itself. Looting and treasure hunting occurs due to either financial reasons, to have a souvenir of the past or as an expression or deliberate evidence that shows that a diver has been there. It was established that looting and treasure hunting took place on known underwater archaeological resources through personal communications with diver and tourists on the island. However, the extent of looting/ treasure hunting that occurred and is currently occurring is unknown. An increase in tourism will subsequently increase the amount of individuals that visit dive sites which in turn can increase the degree of looting and treasure hunting that occurs if there is a lack of rules, guidelines, and supervision. In addition, aside from the underwater archaeological sites, there are currently precolonial sites that are partially submerged and partially present on land. An increase in tourism will result in an increase in visitations to the beaches which in turn can cause damage to the sites present on land located on the coastlines, especially as these sites are situated in the northwestern region, namely *Arashi*, *Malmok*, and *Palm Beach*, and these are the most touristic regions on the island.

Fishing has been an important part of the communities since the beginning of Aruba's habitation history. Fish and shellfish were important sources of food for survival in the past and are now an important source of income for the locals. However, the methods used in present day are very intrusive in regards to the shipwrecks and underwater sites present. The shipwrecks/underwater archaeological resources settle into the environment and become artificial reefs. This in turn attracts a variety of marine life that live around the sites (see figure 41). The marine life cluster in turn form a beneficial fishing spot for fishermen and they therefore tend to anchor on the shipwrecks/sites to catch the fishes living around the underwater archaeological resources. Each time a ship anchors on a shipwreck, parts of it may break off. Thus, the longer a ship is underwater acting as an artificial reef, regardless of it being beneficial to the environment and the marine organisms, the more extensive the damage will be to be structure of the wreck. Based on personal communications with locals and divers on Aruba, two of the most damaged shipwrecks due to anchoring were the SS Antilla located within the *Malmok* bay and the SS Pedernales located at *Palm Beach*. This shows how the five historical shipwrecks could possibly have more extensive damage due to them being underwater longer, with the exception of the sixth unknown shipwreck at *Sero Colorado* as only materials were found.

Figure 41. British Cargo bulk carrier Jane Sea. Source: Mermaid Sports Divers Aruba N.V.: http://scubadivers-aruba.com/projects/13-jane-c-wreck. Accessed on 07-09-2023.

Based on the research conducted by Carmabi in 2019, fishes are more abundant in between the area of *Renaissance island* and *Sero Colorado*, with the exception of the harbor entrance of *Paardenbaai* (Vermeij et al., 2020, p. 28). This region is also where a majority of the future underwater archaeological resources are situated, namely ten out of seventeen (see figure 42). This could indicate that the focus could shift to the region between *Renaissance island* and *Sero Colorado* where the future underwater archaeological resources were sunken to become artificial reefs in turn making them susceptible to future anchorage damage from fishers. It is important to investigate the extent of damage done to the future underwater archaeological resources through fishing activities and to implement mitigation actions as these underwater resources have an economic and historical value to the local communities and the government, and therefore have a high chance of becoming underwater cultural heritage in the future.

In addition, the level of tourism is linked to the degree of fishing that occurs in the waters of Aruba. As the amount of tourism grows, more tourists would visit and want to eat local foods at local restaurants, namely fresh caught fish and seafood. Fishing is the livelihood for a lot of local fishermen. Therefore, as the demand grows for fish and seafood, so will the fishing activities in order to provide the resources and increase their income. As was mentioned above, fish tend to cluster near the underwater archaeological resources, an increase of fishing activities will therefore increase the amount of boats anchoring on the underwater archaeological sites in turn increasing the amount of damage caused to the sites.

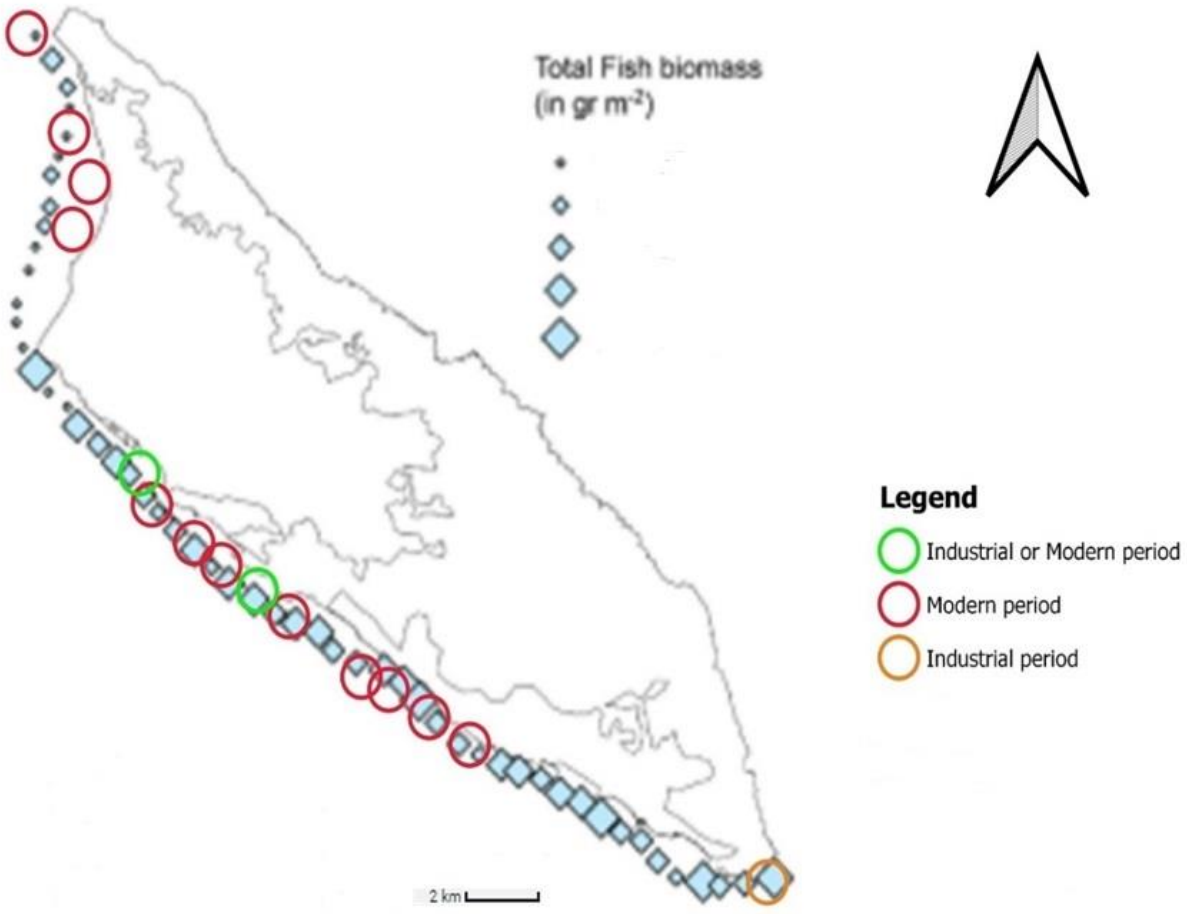


Figure 42. Map of Aruba portraying the distribution of fish per gram/meter with the locations of the future underwater archaeological resources. The blue triangles within this map portray the biomass of fishes present within the underwater landscape on the leeward side of the island. Source: Vermeij et al., 2020, p. 28. Map created by Gendra Lacle.

Dredging occurred in the surrounding waters of Aruba in order to maintain the waterways. The ships that sailed to the island increased in size throughout the habitation history with large cargo ships sailing to Aruba in modern day. The harbors had to therefore be altered in order to be accessible for all ships. This puts development pressure to dredge deeper channels which in turn have direct consequences to the potential (unknown) underwater archaeological resources. Dredging occurred in the regions at *Paardenbaai*, *San Nicolaas*, and *Barcadera*. Dredging began at *San Nicolaas* as part of port improvements in 1937 in order to make the western port entrance at the oil refinery harbor more accessible. The port improvements entailed digging through the reef to make it easier to enter, even at night (Historia di Aruba: http://www.historiadiaruba.aw/index.php?option=com_content&task=view&id=28&Itemid=42). Dredging and underwater blasting continued at *Sint Nicolaas Baai* at reef berths (see figure 43) in the 1960's. High amounts of debris, namely stones, corals, and construction materials, were located near the shore in the shallow regions of *Sint Nicolaas Baai*. The dredging and underwater blasting occurred in order to build a berth, namely the supertanker berths.

Berths are specific locations within a harbor used by mooring vessels when said ships are not at sea. It can be speculated that debris/archaeological materials from the 20th century are present. However, due to dredging and underwater blasting activities occurring from the 1960's onwards, older archaeological materials could have been displaced or destroyed (Eakin *et al*., 1993, p. 140, 142).

After World War II, the attention was turned to the harbor at *Oranjestad* where larger piers were built to accommodate the growing need for more capacity carrying vessels. As was mentioned in chapter 3, four dredging projects took place at *Paardenbaai*. The first dredging occurred in 1916 where the sand around the "waf di Rey" was deepen to circa 5.5 meters. However, the depth of the harbor before dredging began is unknown. The sand from this dredging was then used for construction on land, meaning that possible archaeological materials that could have been present are now lost. Dredging continued after 1930 with the entirety of *Paardenbaai* being deepened to a depth of 6.7 meters. Following the dredging, a pier was built, but only the north side was deeper and more easily accessible for larger vessels. The west entrance of *Paardenbaai* was only 3.7 meters deep, making it attractive for smaller fishing vessels. After 1939, *Paardenbaai* was dredged to a depth of 9.1 meters, and the reefs were removed so that the vessels can turn without issue. The sand dredged was then distributed on both sides of the pier to create a strip of circa 75 meters wide. The last dredging took place between 1947 – 1948, in which the sand was used to construct a strip where multiple buildings were subsequently built on top of it. Therefore the possible archaeological materials present within this sand was either destroyed, lost, or is now located underneath buildings (Awe Mainta, 2021). Lastly, dredging occurred at the *Barcadera* harbor between 2018 and 2022. The sand extracted during the dredging process was used for land reclamation. This means the potential archaeological materials were removed from their original chronological and environmental context, making it difficult to connect it back to a historical moment or rebuild the historical occurrence. The sand was added to land where construction would take place, meaning the potential archaeological materials were destroyed or lost during the dredging and moving process (Dijkhoff, 2023, p. 49-50).

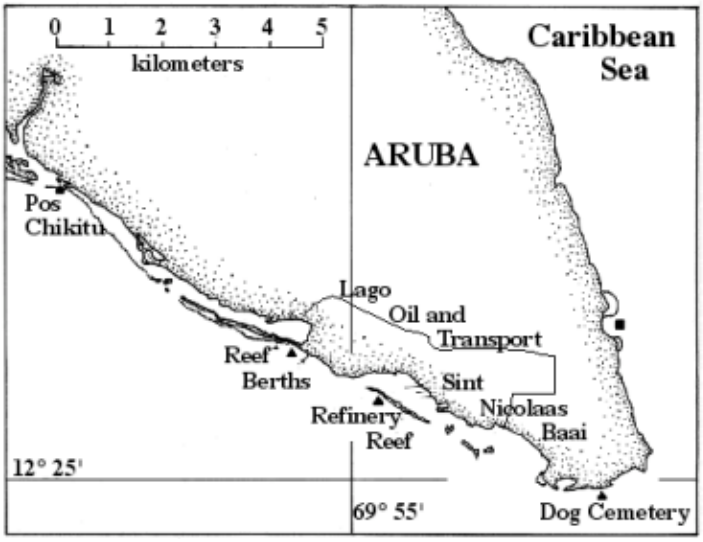


Figure 43. Map of Aruba portraying the southeastern side. Source: Eakin et al., 1993, p. 140.

Socio-political threat factors

Aside from the dredging activities that took place, various human construction activities began taking place during the Colonial and Industrial period as the communities began expanding, demand began growing, and the sizes of vessels coming to and from the island began increasing. Multiple piers were built along the leeward side of the island. During one of these pier constructions, namely at *Paardenbaai* during the early 20th century, as it was mentioned above, archaeological materials were found. However, due to a lack of awareness that in turn connects priority of economic gain with the lack of awareness, namely economic and socio-political threats factors, the archaeological materials were lost.

In modern times, there is a lack of awareness to the immense pressure put on the underwater archaeological resources that function as dive sites from the large amount of visitors to the underwater archaeological resources every day. It must be taken into account that at minimum a portion of the tourists and locals visiting the underwater archaeological resources are novice divers who lack buoyancy control, can flap fins improperly, hold onto parts of the site (mainly the hull on shipwrecks) carelessly, and they can attempt to infiltrate the site when it's not advised. This lack of awareness, knowledge, and experience leads to negligence of the underwater archaeological resources which in turn contributes in the deterioration of the sites and artificial reef, and the disturbance of the marine life. In addition, the lack of knowledge results in a lack of participation from the local communities in the management and preservation of the underwater archaeological resources and marine life. The socio-political threat factors are mostly caused by a lack of policies and regulations (Aruba Today, 2020).

In addition to the lack of awareness for the known and present underwater archaeological resources, there is also a lack of awareness for the potential maritime and underwater archaeological resources present. Thus, when combining this with a lack of policies and development pressure to keep up with the growing tourism, this leads to continuous and large-scale construction activities taking place which in turn causes the displacement, looting, or complete destruction of archaeological materials. In the last three to four years itself, the following accumulation of activities took place that did not take the possibility of archaeological materials being present within the landscape into account, namely the "secret" hotel project in *Sero Colorado*, the restoration of the stairs at *Rodger's beach*, issuing a permit for the construction of a boutique hotel located at *Sero Colorado*, and dredging the *Barcadera* harbor in order to make it accessible for larger cruise ships (Dijkhoff, 2023, p. 5).

4.4. Preservation status

The preservation status of the known, unknown, and future underwater archaeological resources were divided into the ten categories, namely:

- Archaic sites 1500 BC – 900/1000 AD
- Ceramic sites 900/1000 AD – 1515 AD
- Precolonial sites 1500 BC – 1515 AD
- Historical sites including bays 1515 – 1973
- Historical shipwrecks 1515 – 1973
- Historical objects 1515 – 1973
- Historical airplane wrecks 1515 – 1973
- Recent sites 1973 – Present day
- Recent shipwrecks 1973 – Present day
- Recent objects 1973 – Present day
- Recent airplane wrecks 1973 - Present day

An overview of the threats affecting the known, unknown, and future underwater archaeological resources are portrayed in the tables below.

Table 6. Overview of the threat factors affecting the known underwater archaeological resources.

Sites	**Mechanical threat factors**	**Biological threat factors**		**Chemical threat factors**	**Human threat factors**	
	Hurricane - Tropical storms	**Aerobic bacteria**	**Anaerobic bacteria**	**Metal erosion**	**Looting/ treasure hunting**	**Fishing**
Malmok 3	+	-	-	-	-	-
Malmok 5	+	-	-	-	-	-
Arashi 2	+	-		-	-	-
Arashi 5	+	-		-	-	-
Palm Beach 1	+	-	-	-	-	-
Palm Beach 3	+	-	-	-	-	-
Mangel Halto	+	-	-	-	-	-
Spaans Lagoen	+	+	-	+	+	-
Commandeursbaai	+	+	+	+	+	+
The Californian	+	+	-	+	+	+
Unknown shipwreck	+	+	-	+	+	-
SS Antilla	+	-	+	+	+	+
SS Pedernales	+	-	+	+	+	+
SS Oranjestad	+	+	-	+	+	+
SS Arkansas	+	-	+	+	+	-
Cross of Iron pipes	+	+	-	+	-	-

Table 7. Overview of the threat factors affecting regions suspected of containing potential underwater archaeological resources.

Regions	**Mechanical threat factors**	**Biological threat factors**		**Chemical threat factors**	**Human threat factors**	
	Hurricane - Tropical storms - Strong currents	**Aerobic bacteria**	**Anaerobic bacteria**	**Metal erosion**	**Dredging**	**Developmental pressure**
Arashi	+	-	+	+	-	-
Malmok	+	-	+	+	-	-
Palm Beach	+	-	+	+	-	-
Eagle	+	-	+	+	-	+
Oranjestad	+	-	+	+	+	+
Barcadera	+	+	-	+	+	+
Spaans Lagoen	+	+	-	+	-	+
Commandeursbaai	+	-	+	+	-	+
San Nicolaas	+	+	-	+	+	+
Rodger's beach	+	+	-	+	+	+
Andicuri	+	+	-	+	-	-
Bushiribana	+	+	-	+	-	-
West punt	+	+	-	+	-	-
Druif beach	+	+	-	+	-	-
Urirama	+	+	-	+	-	-

Table 8. Threat factors that are affecting the future underwater archaeological resources that must be taken into account when these resources become a part of Aruba's underwater cultural heritage.

Sites	**Mechanical threat factors**	**Biological threat factors**		**Chemical threat factors**	**Human threat factors**	
	Hurricane - Tropical storms	**Aerobic bacteria**	**Anaerobic bacteria**	**Metal erosion**	**Looting/ treasure hunting**	**Fishing**
Colombo	+	+	-	+	-	-
Jane Sea	+	+	-	+		+
Bali Barge wreck	+	-	+	+		
Morning Star	+	+	-	+	+	+
Topaz	+	-	+	+		+
Debbie II	+	-	+	+	+	
Tugboat	+	-	+	+		
Baboo	+	-	+	+	+	
Douglas DC-3 Airplane	+	-	+	+	+	+
Santa Maria	+	-	+	+	+	
Airplane and auto wrecks	+	+	-	+	+	+
Airplane S-11	+	-	+	+	+	+
Kappel tugboat	+	+	-		+	+
Mi Dushi	+	+	-	+	+	+
Lockheed Lodestar	+	-	+	+	+	

Precolonial underwater archaeological resources preservation status

The preservation of the known Archaic and Ceramic sites is not optimal as they are continuously undergoing wind and coastal erosion which are exacerbated by hurricane and tropical storm events. When the archaeological materials, namely shells, pottery, corals, and stones, fall into the ocean they are subsequently subjected to mechanical threat factors as they can be swept away to sea or on shore and be lost due to a lack of awareness and knowledge. Potential precolonial sites situated on the windward side of the island may have been disrupted or completely destroyed by the two tsunami events that occurred in 450 AD, and 1450 – 1550 AD (Scheffers, 2002, p. 26; Scheffers, 2004, p. 167; Scheffers *et al*., 2009, p. 83-84).

Historical underwater archaeological resources preservation status

The preservation of the historical underwater archaeological resources are continuously being affected by mechanical threats, namely hurricanes and tropical storms hitting the entire island which disrupts the locations of the archaeological materials. In addition, the archaeological materials are undergoing metal corrosion and biological deterioration in both an aerobic and an underwater environment depleted of oxygen. Therefore, archaeological materials situated in an anoxic environment present beneficial condition for long-term conservation. However, the natural threat factors, namely biological threats are not completely eliminated as anaerobic bacteria thrive in this environment and ensures a slow degradation process of wood archaeological materials (Frigerio, 2013, p. 291). The materials situated in the aerobic environments may be undergoing a faster deterioration process but the extent of the damage or degradation is unknown. Lastly, the human activities are causing damage through fishing, diving/snorkeling, development and coastal construction pressure, a lack of awareness, and a lack of rules and regulations.

Recent underwater archaeological resources preservation status

The future underwater archaeological resources are all shipwrecks and airplane wrecks, namely twelve shipwrecks and four airplane wrecks situated on the leeward side of the island. The recent underwater archaeological resources are not considered to be underwater cultural heritage as they are under 50 years old. However, due to the economic and historical significance to the communities and the government, the future underwater archaeological resources have a high chance of being considered underwater cultural heritage when they reach the age of 50 years old. They are being affected by threats which needs to be taken into account when they become underwater cultural heritage. The threat factors affecting the recent underwater sites are namely the mechanical factors as the hurricanes and tropical storms hit the entire leeward side of the island.

In addition, the underwater archaeological resources are situated in anoxic and aerobic environments, meaning they are susceptible to varying degrees of chemical corrosion and biological deterioration. Lastly, they are becoming artificial reefs within the ecological environment, and fish species are beginning to cluster near the future underwater sites which makes them beneficial locations for fishing and dive activities. However, these activities can be intrusive and the lack of awareness and rules can cause damage to the sites.

4.5. Summary

As was seen within this chapter, the condition of the known, unknown (potential), and future underwater archaeological resources are vulnerable to physical human activities and environmental conditions. Hurricanes and tropical storms are a yearly occurrence which causes heavy surf conditions, rain, and flooding on the island which can dislodge or destroy archaeological materials. Biological deterioration is present in varying degrees based on the oxygen levels within the environment. The underwater sites situated in the anoxic regions are undergoing slow microbial deterioration while the underwater sites situated in the aerobic environments may be undergoing a more extensive degradation. The same counts for the underwater sites containing metal objects situated within the anoxic and aerobic environments. Human influences are also a threat to the underwater archaeological resources. The fishing methods used are intrusive as the fishermen anchor on the underwater sites which in turn breaks pieces off. In addition, tourism is a large-scale business on Aruba, however not all divers visiting the sites are experienced and this lack of knowledge and reckless behavior can cause damage to the sites themselves. In addition, construction work began in the early 20th century where account was not taken with the potential of archaeological materials present.

The question now is why it is important to preserve Aruba's underwater cultural heritage. This is discussed in the chapter below.

Chapter 5 Importance of managing Aruba's underwater cultural heritage

As was described in chapter 4, Aruba's underwater cultural heritage is constantly under human and natural threats. The (un)known underwater archaeological resources were subjected to natural disasters, climatic factors, biological and chemical attacks, in addition to multiple threats caused by humans. However, actions can be taken to mitigate the natural and human threats by creating an underwater cultural heritage management plan. This chapter focuses on the importance of managing Aruba's underwater cultural heritage either in-situ or ex-situ. The international standard within a management plan is to consider in-situ preservation and protection as the first option when managing an underwater site. What exactly does in-situ preservation and protection of the underwater cultural heritage sites mean and why is it important? This chapter starts by describing the definition and importance of in-situ preservation and protection, followed by why Aruba's underwater archaeological resources should be preserved, and considering the reasons for ex-situ preservation when in-situ is not beneficial.

5.1. Significance assessment

The waters of Aruba contains an abundance of underwater cultural heritage through the presence of underwater archaeological remains. The underwater archaeological remains in turn have an aesthetic, cultural-historical, and economic value. The underwater archaeological resources and sites situated on the leeward side of the island are accessible to everyone to carry out the following activities, namely kayaking, snorkeling, diving, and fishing. Therefore, it is important to assess the significance of the underwater archaeological sites in order to create a priority overview on which sites needs the most attention when it comes to managing and preserving the sites. A significance assessment is needed due to limited resources available. The budget, time, and equipped archaeologists/staff need to be utilized correctly to ensure that the underwater cultural heritage are prioritized accordingly.

Various archaeological research conducted on Aruba indicates that the leeward coastlines of the island was used for the first and subsequent continuous migration of the indigenous people to the island. Afterwards, the coastlines were extensively used in the harvesting and exploitation of marine resources for consumption during the precolonial period (Dijkhoff and Linville, 2004; Kelly and Hofman, 2019). When the island was discovered by the Spaniards, it was used in the trading industry (Alofs and Dalhuisen, 1997). As time went on the island continued to trade and receive products during the period of the Dutch West India Company. The island was used as a breeding landscape for livestock which were then traded (Teenstra, 1836; Hartog, 1953). In addition, salt was also harvested and traded (Alofs and Merkies, 2001, p. 11). The Colonial period brought forth a period of war and depletion of the island resources. The individuals on the island had therefore switched their focus on the trading industry once again with a focus on the northwestern side of the island. Aruba therefore participated in the mercantile industry where they exported livestock, wood, gold, and phosphate (Teenstra, 1836; Hartog, 1953; Hartog, 1961; Hartog, 1980; Bosch, 1985; Alofs and Merkies, 1990; Alofs, 1996; Alofs and Dalhuisen, 1997; Alofs and Merkies, 2001; Dijkhoff and Linville, 2004; Bakker and van der Klooster, 2008; Martis, 2018; Kelly and Hofman, 2019). The Industrial period entailed a period of expansion and construction work and the built of multiple harbors on the leeward side of the island. The coastal construction work was strongly linked to the expanding trade, growing ships, and the oil industry (Alofs and Merkies, 1990;2001; Ridderstaat, 2007; Bakker and van der Klooster, 2013; Dijkhoff, 2021; Awe Mainta, 2021, Lago Oil and Transport CO. Ltd: https://lago-colony.com/).

It is important to make the past part of the future. This can be done by understanding the cultural heritage which in turn makes people value it. By valuing the cultural heritage, both archaeologists and the communities would want to protect and manage it. By managing the underwater cultural heritage, people can continue to enjoy it for generations to come and understand the importance of it. This is important as the underwater cultural heritage is a part of Aruba's history and how the island came to be and should be preserved for generations to come. By creating this underwater cultural heritage management plan, the first step in committing and taking on the responsibility for preserving Aruba's underwater cultural heritage in preparation for the ratification of the UNESCO 2001 convention and the upcoming new laws and legislations are established.

This underwater cultural heritage management plan sheds light to the still remaining hidden past and underwater cultural heritage in addition to what can be causing them harm and how to best present and research these sites.

In-situ preservation is recommended as the first (but not only) option within this thesis report as the ratification of the UNESCO 2001 convention and laws and legislations regarding the management of the underwater cultural heritage has yet to be finalized. Thus preservation in-situ is recommended at minimum for the period up until definitive management measures are in place and research and excavations can be carried out. An important starting point for the priority assessment is to question why it is needed to preserve the site in-situ which can be based on cultural heritage influences namely scientific values, aesthetic values, enjoyment or commemoration. In addition, the economic influx, namely the economic developments, use of the area, and how profits can be gained from the heritage are taken into account. In-situ preservation is defined within this thesis report as the location where the underwater archaeological resource or materials thereof were discovered laying in or on the seabed (Manders, 2017, p. 101). It must be taken into account that in-situ preservation does not completely stop the degradation process, and therefore continuous and active involvement in the preservation and in-situ process is needed in order for it to be effective. In addition, all measures taken to preserve the underwater archaeological resources in-situ may be temporary.

5.2 Arguments for in-situ preservation

It is important to preserve the known and future shipwrecks in-situ as these are now artificial reefs housing a variety of marine organisms and fish species. This in turn made them important locations for fishermen, who are important stakeholders in the management of Aruba's underwater cultural heritage. Fishing communities are able to provide valuable and substantial information on where potential shipwrecks and other precolonial and historic sites are situated. In addition, as was mentioned within this thesis report, the shipwrecks are of economic importance for fishermen. Therefore, by preserving the site in-situ and working with the fishermen, the deterioration of the wrecks can be mitigated against in addition to preventing a decline of the biodiversity and economic potential. With the underwater archaeological resources becoming artificial reefs, three of the known underwater archaeological resources and fourteen of the future underwater archaeological resources are popular dive and snorkel sites, which in turn provide positive economic gain for the island (see table 9). The underwater archaeological resources that act as dive and snorkel sites became a part of Aruba's identity as these underwater sites portray the history of Aruba and what was left behind within the landscape to the local communities and tourists who come to see them.

Table 9. Overview of the underwater sites that are used as fishing and dive/snorkel locations.

Category	Underwater site	Fishing location	Dive/snorkel location
Known underwater sites	SS Antilla	✓	✓
	SS Pedernales	✓	✓
	Cross of Iron pipes	✓	✓
Future underwater sites	Jane Sea	✓	✓
	Bali barge wreck	✓	✓
	Morning Star	✓	✓
	Topaz	✓	✓
	Debbie II/Coralshell	-	✓
	Tugboat shipwreck	✓	✓
	Baboo	-	✓
	Douglas DC-3 airplane	✓	✓
	Star Gerren/Santa Maria	✓	✓
	Airplane and auto wrecks	✓	✓
	Airplane S-11	✓	✓
	Kappel tugboat	✓	✓
	Mi Dushi	✓	✓

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Choosing to preserve in-situ is also influenced by the chemical and biological threat factors. As was mentioned within this thesis report, anoxic environments are present. The wood materials situated in an anoxic environment are undergoing slow deterioration processes through the presence of anaerobic erosion bacteria. However, the wood materials are no longer stable when taken out of the anoxic environment as the bacteria causes the wood to become fragile. Therefore, the wood materials present within the known, unknown, and future ship-, and airplane wrecks situated within the anoxic environments should be preserved in-situ, in addition to being stabilized. Also, the archaeological wood materials situated within an oxygen rich environment should be stabilized through the creation of an anoxic environment surrounding the underwater archaeological site. This can be done through different, which are explained in chapter 6.

When it comes to chemical corrosion, the less oxygen present within the environment the less corrosion that occurs. Anoxic environments are present in the surrounding waters of Aruba in which the underwater archaeological resources reside in, namely the known harbor and sites at *Commandeursbaai*, the known shipwrecks SS Antilla, SS Pedernales, SS Arkansas, and the future underwater archaeological resources namely Jane Sea, Bali barge wreck, Morning star, Topaz, Debie II, Tugboat shipwreck, Baboo, Douglas DC-3 airplane, Santa Maria/Star Gerren, airplane S-11, Mi Dushi, and Lockheed Lodestar airplane. Therefore, the underwater archaeological resources are being affected by slow metal corrosion and should remain in-situ, in addition to attempts of stabilizing or slowing down the metal corrosion further. Constant monitoring is needed to continuously measure the oxygen levels present as these underwater archaeological resources also serve as dive sites which in turn can introduce oxygen into the environment. Aside from the anoxic environment slowing down the metal corrosion, the marine concretions forming on the shipwrecks as part of the formation of the artificial reefs also slow down the metal corrosion and therefore it is more beneficial for them to remain in-situ. However, continuous monitoring is also needed as natural disasters, namely hurricanes and tropical storms, can remove the concretions which in turn exposes the metal to the seawater and oxygen and this accelerates the deterioration. Thus, it is important to actively manage the underwater archaeological resources as they are undergoing continuous chemical and biological deterioration.

Besides in-situ preservation being beneficial for the cultural heritage and economy of Aruba, it is also beneficial in regard to time and costs as underwater archaeology is very expensive when taking the special equipment, expertise, limited time and visibility leading to more time needed, and the weather into account. In addition, preserving large-scale excavations is difficult and adequate conservation for certain archaeological materials may not be an option. However, the costs of managing an underwater cultural heritage site in-situ for the long term can also run up quickly, which in turn falls under reasons why preservation in-situ is not beneficial. This is explained further below.

5.3 Arguments for ex-situ preservation

Mitigations can be taken against the natural threat factors but they are still continuous degradation processes. The small material analysis indicated that the smaller iron objects are undergoing faster chemical erosion (see figures …). A portion of the underwater archaeological resources are now situated in an anoxic environment created through the action of people. Therefore, this could be slowing down the metal corrosion occurring, but constant monitoring is still required to document the degree of corrosion.

In addition, the regions between *Barcadera* and *Mangel Halto* and *Rodger's beach* and *Sero Colorado* are aerobic environments where the known metal objects are situated on the seafloor and therefore subjected to oxygen and are undergoing metal corrosion. However, the extent of the damage on the underwater sites are unknown. If the levels of corrosion occurring is still extensive and threating to completely destroy the metal objects, in turn losing valuable information regarding the site and the environmental context, excavations can take place by archaeological professionals where the location and context of the object are documented and photographed, then lifted and preserved ex-situ where the materials will go through metal preservation and conservation processes. The same situation counts for the wood materials situated within the aerobic environments as these are susceptible to microbial deterioration and shipworms. However, more extensive research into the chemical and biological deterioration needs to be conducted before ex-situ preservation becomes an option.

The mechanical threat factors cannot be controlled or maintained and continue to occur every year. As was mentioned, hurricane and tsunami events cause an up spit of debris on the coastlines. When this occurs, archaeological professionals should survey the coastlines and extract what they deem to be of archaeological value. This is not an ideal situation as the archaeological materials were taken out of their environmental and chronological context and would be difficult to link back to a specific site unless the archaeological material is specific or known for a site. However, by excavating the archaeological materials and storing them in the National Archaeological Museum Aruba, the information of the archaeological material are therefore not lost. A different level of value remains attached to the archaeological artefacts that are excavated, restored, and presented within the museum. These archaeological artefacts provide more knowledge about the history of Aruba through stories and beautiful objects presented within the museum. This in turn shows the identity of and history of Aruba through a different view as not everyone is capable of visiting the dive and snorkel sites.

5.4. Summary

The underwater cultural heritage of Aruba should be managed as it portrays the island's history, culture and identity. However, the underwater cultural heritage is undergoing mechanical, biological, chemical, and human caused degradation, and should therefore be actively managed to mitigate against these threats. When looking at the economic significance of known and future underwater archaeological resources situated within the anoxic environments which are reducing the chemical and biological deterioration occurring, these sites should remain and be preserved in-situ. In regard to the archaeological materials situated in the aerobic environments should be monitored based on the extent and how fast the degradation is occurring. Mitigation methods need to be implemented to create an anoxic environment or reduce oxygen levels present that slows down the deterioration. If the deterioration is threatening to destroy the archaeological materials, steps should be taken by archaeological professionals to preserve the materials ex-situ. Lastly, if hurricane and tropical storms causes spit up of debris to come ashore, the archaeological materials should be extracted by archaeological materials and stored ex-situ. When archaeological artefacts needs to be lifted out of their underwater context, or was expelled from the sea due to hurricane tropical storm activities, it gets a different value. The archaeological artefacts can therefore be portrayed within the National Archaeological Museum Aruba and tell the story to a different group of tourists.

Now that the importance of why Aruba's underwater cultural heritage should be managed has been explained, how to manage Aruba's underwater cultural heritage needs to be expanded on. The following chapter discusses the mitigation methods that can be implemented to mitigate against the threat factors.

Chapter 6 Managing Aruba's underwater cultural heritage

After insight was gained into the threat factors affecting the underwater archaeological resources, and why they should be preserved, measures to mitigate against these threat factors can be taken. The measures taken are a combination and a compromise of the value (archaeological, scientific, cultural, or economic) of the site, the reasons why it should be preserved, the expected results of the mitigation strategies, the time needed for the mitigation strategies to be effective, the effects the mitigation strategies will have on the environment, and the resources required. Mitigation strategies towards in-situ preservation strive to protect sites in their original position and context, to preserve and protect the underwater archaeological resources in their current conditions, in addition to preserving the archaeological integrity for as long as possible. Therefore, a key aspect in this underwater cultural heritage management plan is to implement continuous monitoring of the underwater cultural heritage in order to consistently investigate and document the preservation status and the conservation measures taken. This chapter therefore discusses the recommended methods to preserve the underwater archaeological resources in-situ and the measures and methods needed to preserve the threatened underwater resources ex-situ. Given the fact that the chemical and biological deterioration of the underwater archaeological resources are relatively slow processes, more priority was put on mitigating the mechanical and human threat factors. Based on the cultural and economic importance of the underwater archaeological sites, the protective measures should be chosen based on the capacity to minimize the threat factors in addition to maintaining accessibility to the site for future enjoyment and research. When it comes to managing Aruba's underwater cultural heritage, the National Archaeological Museum Aruba is the central point in the management and conservation of the underwater cultural heritage. In addition, the National Archaeological Museum Aruba is tasked with ensuring that the execution and implementation of the management plan and the ratification of the UNESCO 2001 convention is done properly. This underwater cultural heritage management plan advices the National Archaeological Museum Aruba to regularly document the preservation status of the underwater cultural heritage and make an alert when or if the agreements, laws, and legislations are not being met.

6.1. Management of the underwater cultural heritage

The following mitigation measures need to be taken to preserve Aruba's underwater cultural heritage for the foreseeable future which are presented in tables 10-12.

Desk-based assessment and follow up research

This thesis report conducted the first step, which was a desk-based assessment in order to acquire information from known and future resources, in addition to portraying the regions containing potential underwater archaeological resources. If underwater archaeological resources are expected to be present within a region, a follow-up research is required. A database was created during the desk-based assessment conducted within this thesis report, where the known and future underwater archaeological resources and regions were documented (see attachment 1). As the follow-up researches are being conducted, coastal developments are not going to be put on hold. Therefore, as the follow-up researches are being carried out, an archaeological watching brief needs to implemented. An archaeological watching brief entails the continuous surveillance and identification of archaeological remains while groundwork is being carried out. Thus, the National Archaeological Museum Aruba needs to be informed when coastal developments are being done in order to assess if this region has archaeological value or potential. If the construction region demonstrates the potential of containing archaeological remains, a qualified archaeologist needs to be present to monitor all intrusive groundwork being done up until the work is complete (Wessex archaeology: https://www.wessexarch.co.uk/archaeological-services/watching-brief#:~:text=and%20during%20development.-,Watching%20briefs%20are%20an%20ongoing%20process%20designed%20to%20ensure%20archaeological,and%20utility%20trenching)%20is%20underway). The archaeologist is present in a passive capacity. However, when archaeological remains are found, the archaeologist is required to document the site, photograph and draw the artefacts, and eventually lift it to preserve at the National Archaeological Museum Aruba. In order to achieve an archaeological watching brief, the National Archaeological Museum Aruba needs to have a partnership with developers.

The recommended follow-up research within this thesis report is in the form of a prospection. A prospection is a non-destructive research method to identify potential underwater archaeological resources present underwater. The following marine geophysical techniques can be implemented based on the landscape characteristics, namely multibeam sonar, side-scan sonar, sub-bottom profiling, magnetometer, and remotely operated underwater vehicles.

Marine geophysical techniques are non-destructive methods that make use of acoustic signals from the surface to detect potential underwater archaeological resources lying on the sea bed (Houkes et al., 2017, p. 22). Marine geophysical techniques need to be implemented in analyzing the presence of potential underwater archaeological resources as it gives an overview of sites that are present but are not visible to the naked eye due to being covered with sediment or vegetation, and therefore not accessible to divers. During the follow-up research, the potential sites are inspected and if determined to indeed be of archaeological value, the site is recorded, documented, and photographed, which in turns leads to the next mitigation method, namely monitoring and documentation.

Monitoring in-situ and documentation

The most important element that needs to be implemented to mitigate against the threat factors affecting Aruba's underwater cultural heritage, is the constant and continuous monitoring of the underwater archaeological resources as the site remains in its original location and context. Monitoring requires continuous surveying and documentation of the changes occurring at the underwater archaeological sites over a period of time (Manders, 2017, p. 143). The degree of monitoring is dependent on the budget, the amount of people available and their respective experience and qualifications, the amount of sites present, the extent of the threats, why they need to be preserved in-situ and the goals to manage it. In addition, the environmental context needs to be taken into account. The following information needs to be collected as the first step in conducting a baseline study of the underwater cultural heritage, namely:

- The current significance of the site
- The size of the underwater site
- The relationship of the underwater site within its environmental context
- The preservation status
- The materials present
- A review of the past, current, and future threats.

Underwater archaeological sites can be monitored in different ways. However, based on the depth (between one and eighteen meters) and the good visibility of the known underwater archaeological resources, a combination of divers and geophysical methods from the surface needs to be implemented. By combining these two methods, the site itself, the natural environment and the preservation of the materials can be assessed.

During the archaeological dive surveys, samples should be taken of the different archaeological materials to analyze the short and long term changes occurring due to the natural and human threat factors. In addition, the environment itself must also be continuously monitored as changes within the landscape can expose potential underwater archaeological sites and these need to be documented, the historical resources are analyzed, the site itself is assessed, and mitigation methods must be implemented. The new sites are then implemented into the database created for this research (Manders, 2017, p. 143-144).

Spreading awareness

Another important mitigation method that needs to be implemented is to inform and spread the awareness that Aruba has underwater cultural heritage, what they are, and what is threatening them. The exact location of the underwater cultural heritage are not going to be provided to the local communities as this can be dangerous in regards to making the sites vulnerable to illegal salvaging and looting. As was made clear from the locals surveys conducted, there is a lack of awareness and knowledge from the Aruban communities regarding its underwater cultural heritage. This therefore leads to an unwillingness to protect and manage these sites as it is not understood nor valued. By informing and educating the local fishers and dive companies on Aruba, they can in turn continue to educate locals and tourists and ensure during the diving expeditions that the sites are not damaged or looted. However, raising awareness among the local communities can also occur by implementing this within the social media, presentation, and the school curriculum.

Mooring lines

Mooring lines should be implemented at the known and future shipwrecks, more speficially on the known shipwreck SS Antilla, SS Pedernales as these two are the most damaged by anchoring and fishing activities, in addition to SS Oranjestad and SS Arkansas, and the future shipwrecks situated between *Oranjestad* and *Sero Colorado*. This ensures that fishermen can continue to exploit the regions with high clusters of fish, in addition to mitigating against the continuous breakage of parts and materials off the shipwrecks when the fishermen anchor their vessels.

Barrier methods

In order to mitigate against looting/treasuring hunting and the dislodging/relocation of archaeological materials, barrier methods can be put into place. Artificial barriers were chosen to mitigate against looting/treasure hunting and the displacement of archaeological materials that do not affect the visibility of these dive sites. In regard to the known underwater archaeological resources, the precolonial sites and the religious symbol does not need barriers. However, the known shipwrecks do. Given the size and depth of the SS Antilla and SS Pedernales, barrier methods would probably not be beneficial, and strict guidelines and laws and legislations should be implemented first. If this does not work, the implementation of metal barriers should be discussed. However for the SS Arkansas did not sink, but materials had broken off and sank to the ocean floor. In order to ensure that further lifting of materials do not occur, a metal barrier method, namely underwater steel cages, should be implemented on the archaeological materials from the SS Arkansas located at Eagle Pier, the Californian situated at north tip of Aruba, and possible lose materials, for example anchors, from the SS Oranjestad. Underwater steel cages were chosen within this report as these ensures that the underwater archaeological artefacts remain visible for the yearly site assessments.

Covering a site

The underwater archaeological resources can be mitigated against using different covering methods, namely sandbags, geotextiles or debris nets. Aside from barrier methods, implementing sandbags can mitigate against looting/treasure hunting, in addition to helping reduce erosion. Sandbags can create anoxic environments which help reduce a lack oxygen in the environment in turn reducing the chemical and biological deterioration. However, sandbagging is the most effective when implemented in small regions or on smaller archaeological materials that are being threatened by the current (Manders, 2017, p. 121). When looking at underwater archaeological resources situated in the aerobic envioronments, namely between *Barcadera* and *Mangel Halto*, and *Rodger's beach* to *Sero Colorado*, loose materials from the SS Oranjestad could be covered with sandbags that have metal or wood materials. In addition, from recent research conducted at *Spaans Lagoen* and *Commandeursbaai* (Symister and Dijkhoff, 2022), a total of 27 new sites came to light at these locations which contained metal and wood materials. Therefore, sandbags could be implemented to create an anoxic environment in order to reduce the biological and chemical degradation and to maintain the sites in-situ. Lastly, the anchorage locations on the leeward side of the island needs to be assessed to determine which needs the implementation of sandbags. The same counts with the sites situated between *Barcadera* and *Sero Colorado*.

However, it must be taken into account that by covering the archaeological artefacts with sandbags can create an “out of sight, out of mind” mentality where the value may decrease. Geotextiles are finely woven artificial materials that can be implemented to reduce or prevent coastal erosion (Manders, 2017, p. 121). Geotextiles should be implemented at the known precolonial settlements situated on the coastline as (temporary) mitigation actions to prevent further erosion where the archaeological materials present are falling into the ocean, namely the settlements. Another mitigation method that could be implemented in tandem with the geotextiles is to add another layer of sand on top of the precolonial settlements sites that are now undergoing continuous wind and coastal erosion. In addition, multiple anchors were located and recovered between *Arashi* and *Eagle beach* as this location was used as an anchorage location since the period of the Dutch West India Company onwards. When more anchors are found in the future, it should be documented, photographed, and an added layer of sand could be put on top of it. However, this also creates an “out of sight, out of mind” situation, and the decision to adding a layer of sand needs to be weighed and discussed. This is to ensure that the environment remains depleted of oxygen and the chemical erosion can be reduced as majority of anchors are made out of metal, in addition, to protecting the archaeological object from being looted or lifted by locals and not archaeological professionals from the National Archaeological Museum Aruba. Debris nets functions as a loosely fitted net over archaeological materials in underwater environments where currents are present. It works similar to artificial seagrass and can therefore be implemented in regions surrounding Aruba that are not covered in seagrass. The current and sediment transport work together to create a burial mound underwater, in turn protecting the underwater archaeological resources (Manders, 2017, p. 124).

Based on the historical information, the threat factors, and mitigation methods that can be implemented, the following steps are discussed in table 11 to conduct efficient follow-up research and site assessments, in addition to the underwater cultural heritage management plan described in table 12 .

Table 10. Overview of the mitigation methods that could be implemented to manage Aruba's underwater cultural heritage.

Sites	Monitoring	Spreading awareness	Mooring lines	Metal barriers	Sandbags	Debris nets	Geotextiles	Added sand layer
Malmok 3	✓	✓	-	-	-	-	✓	✓
Malmok 5	✓	✓	-	-	-	-	✓	✓
Arashi 2	✓	✓	-	-	-	-	✓	✓
Arashi 5	✓	✓	-	-	-	-	✓	✓
Palm Beach 1	✓	✓	-	-	-	-	✓	✓
Palm Beach 3	✓	✓	-	-	-	-	✓	✓
Mangel Halto	✓	✓	-	-	-	-	✓	✓
Spaans Lagoen	✓	✓	-	-	✓	✓	-	-
Commandeursbaai	✓	✓	-	-	✓	✓	-	-
The Californian	✓	✓	-	✓	✓	✓	-	-
Unknown shipwreck	✓	✓	-	-	✓	-	-	-
SS Antilla	✓	✓	✓	-	-	-	-	-
SS Pedernales	✓	✓	✓	-	-	-	-	-
SS Oranjestad	✓	✓	✓	✓	✓	✓	-	-
SS Arkansas	✓	✓	✓	✓	✓	✓	-	-
Cross of Iron pipes	✓	✓	-	-	-	-	-	-

Table 11. Potential efficient steps to manage the underwater cultural heritage of Aruba.

Steps for the efficient management of the underwater cultural heritage	
1. Desk-based assessment	The desk based assessment utilized historical information from documented sources, maps, and photographs, known and documented archaeological remains, the landscape characteristics and threat factors affecting the underwater archaeological resources.
Objective	Actors
Obtain information from existing resources to create a database of the known, unknown (potential), and future underwater archaeological resources with an overview of the natural and human threat factors affecting the archaeological remains.	BA/MA/KNA senior (maritime and underwater) archaeologist
Process	Resources
▪ Collecting data ▪ Creating a database for the known underwater archaeological resources ▪ Creating a database portraying the unknown/potential regions that could contain underwater archaeological resources ▪ Create a database for the future underwater archaeological resources ▪ Create overview of the natural and human threat factors	▪ Geological data ▪ Environmental data ▪ Vegetation data ▪ Historical sources ▪ Historical maps ▪ Historical photographs ▪ Archives ▪ Publications ▪ Reports from the National Archaeological Museum Aruba ▪ Oral history ▪ Information from locals, divers, fishermen, and amateur archaeologists.

No archaeological value expected	Passive archaeological watching brief during coastal developments
Archaeological value expected	▪ Follow up research before coastal developments 1. Implementation of marine geophysical techniques 2. Underwater survey from experienced divers ▪ Passive or active archaeological watching brief during coastal developments

2. Archaeological watching brief	
Objective	Actors
Assessing if a region set to undergo coastal development and consutrction may contain potential archaeological remains and if so, provide a passive or active role during the initial groundwork activities.	BA/MA/KNA senior (maritime and underwater) archaeologist
Process	Resources
▪ Desk-based assessment report ▪ Known, unknown, future underwater archaeological resources database ▪ Project outline ▪ Project plan of approach ▪ Carrying out archaeological watching brief ▪ Write daily and weekly results of the archaeological watching brief ▪ Analyze and report results of the archaeological watching brief ▪ Submit documentation to depot of the National Archaeological Museum Aruba	▪ Archaeologist to analyse the reports, project outline and project plan of approach ▪ Archaeologist to carry out the archaeological watching brief, through passive observations or active interventions ▪ Archaeologist to document, present, and submit the results in the depot of the National Archaeological Museum Aruba.

<table>
<tr><th colspan="2">Simultaneous occurrence</th></tr>
<tr><td colspan="2">3. Follow-up research: Marine geophysical techniques</td></tr>
<tr><td>Objective</td><td>Actors</td></tr>
<tr><td>Non-destructive methods to detect or determine if a region contains archaeological remains or an archaeological site is laying on the seabed.</td><td>▪ BA/MA/KNA senior (maritime and underwater) archaeologist
▪ Geologist
▪ Geophysicist
▪ Captain</td></tr>
<tr><td>Process</td><td>Resources</td></tr>
<tr><td>▪ Desk-based assessment reports
▪ Written PO and PoA
▪ Notifying the local coast guard
▪ Carrying out the marine geophysical techniques
▪ Write daily and weekly reports
▪ Process results and analyze sonar images
▪ Document and submit results within a digital or analog documentation to the depot of the National Archaeological Museum Aruba</td><td>▪ Side-scan sonar
▪ Multi-beam sonar
▪ Sub-bottom profiling
▪ Magnetometer
▪ Remotely operated underwater vehicle (ROV)
▪ Boat</td></tr>
<tr><td colspan="2">Follow-up research: Underwater dive surveys</td></tr>
<tr><td>Objective</td><td>Actors</td></tr>
<tr><td>Divers conduct underwater surveys where a description of the surrounding seabed is given in addition to the inspection and documentation of potential underwater archaeological remains present.</td><td>▪ BA/MA/KNA senior (maritime and underwater) archaeologist
▪ Dive team leader
▪ Safety diver
▪ Advanced divers
▪ Captain</td></tr>
</table>

Process	Resources
▪ Desk-based assessment report ▪ Report of the marine geophysical techniques analysis ▪ Written PO and PoA ▪ Notifying the local coast guard ▪ Carrying out dive surveys ▪ Write daily and weekly reports ▪ Analyze and process the context, finds, and samples ▪ Report and create a document of the results ▪ Submit the documentation to the depot of the National Archaeological Museum Aruba	▪ Scuba equipment ▪ Foldable ruler ▪ Tape measurement ▪ Drawing slate ▪ Rope ▪ Camera ▪ Boat
No archaeological remains found or detected	Deselection
Archaeological remains found or detected	▪ Archaeological significance assessment ▪ Preservation status
4. Archaeological significance assessment	The archaeological assessment analyzed the importance of the found archaeological remains in the cultural-historical history context of Aruba, the vulnerability of the underwater archaeological remains in relation to the natural and human activities occurring in the region, thus the preservation status, and whether the archaeological remains could remain in-situ and be monitored
Objective	Actors
Assess the archaeological value from the local communities and stakeholders perspective and the archaeological value of the site based on the preservation status of the site and the materials	▪ BA/MA/KNA senior (maritime and underwater) archaeologist ▪ BA/MA marine biologist ▪ Dive team leader ▪ Safety diver ▪ Advanced divers ▪ Captain

Process	Resources
▪ Archaeological significance assessment report ▪ Written PO and PoA ▪ Notifying the local coast guard ▪ Carrying out the significance assessment based on the importance of the archaeological remains to the local communities and stakeholders ▪ Carrying out the dive inspections to determine the preservation status of the site and the materials ▪ Write daily and weekly reports ▪ Analyze and process the context, finds, and samples ▪ Report and create a document of the results ▪ Formulate advice for preservation ▪ Submit the documentation to the depot of the National Archaeological Museum Aruba	▪ Widespread surveys ▪ Scuba equipment ▪ Foldable ruler ▪ Tape measurement ▪ Drawing slate ▪ Rope ▪ Camera ▪ Site recorder ▪ Photogrammetry ▪ Boat
Advised to preserve in-situ	In-situ preservation, monitoring, and documentation
Advised to preserve ex-situ	Preservation ex-situ through excavation
5. Preservation in-situ with monitoring	The preservation and management of Aruba's underwater cultural heritage through in-situ protection as the first option
Objective	Actors
Aims to create a sustainable long term preservation plan for the archaeological remains and sites present to utilize as a continuous source of knowledge. Therefore, extensive and continuous monitoring is required to assess and mitigate against the natural and human threats affecting the underwater archaeological remains.	▪ BA/MA/KNA senior (maritime and underwater) archaeologist ▪ BA/MA marine biologist ▪ Marine park rangers ▪ Geologist ▪ Geophysicist ▪ Dive team leader ▪ Safety diver ▪ Advanced divers ▪ Captain

Process	Resources
▪ Site management plan ▪ Monitoring plan ▪ Mitigation methods 1. Spreading awareness 2. Implementing mooring lines 3. Implementing barrier methods 4. Covering a site	▪ Social media ▪ Schools ▪ Presentation hall in the National Archaeological Museum Aruba ▪ Photogrammetry ▪ Multibeam sonars ▪ Sub-bottom profiling ▪ Remotely operated underwater vehicle (ROV) ▪ Scuba equipment ▪ Foldable ruler ▪ Tape measurement ▪ Drawing slate ▪ Rope ▪ Camera ▪ Boat
6. Preservation ex-situ	
Objective	Actors
Document and lift archaeological remains in order to preserve the artefacts ex-situ and retain the archaeological and scientific information that are important to conduct research to gather insight into the past.	▪ BA/MA/KNA senior (maritime and underwater) archaeologist ▪ BA/MA marine biologist ▪ Dive team leader ▪ Safety diver ▪ Advanced divers ▪ Captain

Process	Resources
▪ Follow-up research reports ▪ Written PO and PoA ▪ Notifying the local coast guard ▪ Carrying out the excavation ▪ Write daily and weekly reports ▪ Analyze and process the context, finds, and samples ▪ Report and create a document of the results ▪ Formulate advice for preservation ▪ Submit the documentation to the depot of the National Archaeological Museum Aruba	▪ Scuba equipment ▪ Foldable ruler ▪ Tape measurement ▪ Drawing slate ▪ Rope ▪ Camera ▪ Site recorder ▪ Photogrammetry ▪ Boat

Table 12. Aruba's underwater cultural heritage management plan.

1. Administrative details	
Date	15-12-2023
Client	Leiden University
Executed by	Gendra Laclé
Location research area	Aruba
Coordinates	12.5211°N 69.9683°W
Environmental context	
Coastal geology	The coastal geology of Aruba contains soils from the Holocene, namely alluvial mud and sand at Savaneta and San Nicolaas, calcareous beach and dune sand at Palm Beach, Eagle beach, Oranjestad, the north tip, Boca Grandi, and Bachelor's beach, and coral formations along the entire western coastline. The rest of the coastline consist of shallow marine limestones.
Climate	Semi-arid tropical marine climate
Flora and fauna	Benthic groups ▪ Coral reefs ▪ Seagrass ▪ Macroalgae ▪ Turf algae ▪ Cyanobacteria ▪ Crustose coralline algae ▪ Gorgonian corals ▪ Sponges ▪ Mangroves Fauna ▪ Shellfish ▪ Turtles ▪ Crabs ▪ Herbivorous fish ▪ Carnivorous fish ▪ Invertivores fish ▪ Omnivorous fish ▪ Piscivorous fish ▪ Planktivorous fish

Human impact	▪ Coastal developments ▪ Fishing ▪ Dredging ▪ Tourism
Site definition	
Aruba has a total of seventeen known underwater archaeological resources:	
1. Malmok Salina	▪ Precolonial settlement ▪ Surveyed ▪ Not protected ▪ Mechanical threats ▪ Date of assessment to be confirmed
2. Malmok 4	▪ Precolonial settlement ▪ Surveyed ▪ Not protected ▪ Mechanical threats ▪ Date of assessment to be confirmed
3. Arashi 2	▪ Precolonial settlement ▪ Surveyed ▪ Not protected ▪ Mechanical threats ▪ Date of assessment to be confirmed
4. Arashi 5:	▪ Precolonial settlement ▪ Surveyed ▪ Not protected ▪ Mechanical threats ▪ Date of assessment to be confirmed
5. Palm Beach 1	▪ Precolonial settlement ▪ Surveyed ▪ Not protected ▪ Mechanical threats ▪ Date of assessment to be confirmed

6. Palm Beach 3	▪ Precolonial settlement ▪ Surveyed ▪ Not protected ▪ Mechanical threats ▪ Date of assessment to be confirmed
7. Mangel Halto	▪ Precolonial settlement ▪ Surveyed ▪ Not protected ▪ Mechanical threats ▪ Date of assessment to be confirmed
8. Spaans Lagoen	▪ Historic period ▪ Surveyed ▪ Protected as a marine environment Not protected as an underwater archaeological site ▪ Mechanical threats Chemical threats ▪ Date of assessment to be confirmed
9. Commandeursbaai	▪ Historic period ▪ Surveyed ▪ Not protected ▪ Mechanical threats Chemical threats ▪ Date of assessment to be confirmed
10. Unknown shipwreck	▪ Historic period ▪ Not surveyed or researched ▪ Not protected ▪ Mechanical threats Chemical threats

11. The Californian	▪ Historic period ▪ Not surveyed or researched ▪ Not protected ▪ Mechanical threats Chemical threats Biological threats Human threats ▪ Date of assessment to be confirmed
12. ES Antilla	▪ Historic period ▪ Not surveyed or researched ▪ Not protected ▪ Mechanical threats Chemical threats Biological threats Human threats ▪ Date of assessment to be confirmed
13. SS Pedernales	▪ Historic period ▪ Not surveyed or researched ▪ Not protected ▪ Mechanical threats Chemical threats Biological threats Human threats ▪ Date of assessment to be confirmed
14. SS Oranjestad	▪ Historic period ▪ Not surveyed or researched ▪ Not protected ▪ Mechanical threats Chemical threats Biological threats Human threats ▪ Date of assessment to be confirmed

15. SS Arkansas	▪ Historic period ▪ Not surveyed or researched ▪ Not protected ▪ Mechanical threats Chemical threats Biological threats Human threats ▪ Date of assessment to be confirmed
16. Cross of Iron Pipes	▪ Historic period ▪ Not surveyed or researched ▪ Not protected ▪ Mechanical threats Chemical threats ▪ Date of assessment to be confirmed

2. Introduction

2.1 Previous studies

Surveys were conducted by the National Archaeological Museum Aruba at the precolonial settlement sites of Malmok, Arashi, Palm Beach, and Mangel Halto (see attachment …). The surveys entailed in field searches, documentation, and photographing archaeological remains and sites. The goal of the surveys were to determine which archaeological materials were present, where they are situated, and what is currently threatening them. During the surveys, (fragmented) shells, pottery, corals, and stones (Digital files on hand, National Archaeological Museum Aruba, Oranjestad, Aruba).

In 2021, a non-intrusive maritime archaeological assessment was carried out at Spaans Lagoen in the form of a survey and dive inspections. The underwater archaeological remains found were analyzed, documented, sketched, photographed, and videos were taken. In addition, the climate, geological data, environmental conditions, and hazards to the landscape and archaeological remains were analyzed. During the survey a total of 12 sites were found containing constructing materials, fishing traps, shipwrecks, floating platforms, anchors, industrial materials, cannons, petrified wood, and a large abundance of bottles (Symister and Dijkhoff, 2022).

Two surveys were conducted at Commandeursbaai. A maritime archaeological field evaluation in the form of dive inspections were carried out in 2000 by Stichting Marien Archaeologisch Onderzoek Nederlandse Antillen (STIMANA). Several locations were surveyed within Commandeursbaai yielding several artefacts spanning a time frame of 1800 – 1950. The artefacts were bottes, which were lifted and are now property of the National Archaeological Museum Aruba. The 2021 survey yielded a total of 15 locations where underwater archaeological remains were found. The artefacts were namely bottles, fishing and harbor materials, anchors, shipwrecks, propellors, ballast stones, cannons, military and industrial/construction materials, car wrecks, and perishable wood (Angela, 2001; Symister and Dijkhoff, 2022).

2.2. Historical context

Aruba has been inhabited for circa 3500 years, which are distributed into three main time periods:

1. Archaic period 1500 BC – 900/1000 AD
2. Ceramic period 900/1000 AD – 1515 AD
3. Historic period
    - Spanish period 1515 – 1636
    - Dutch West India Company 1636 – 1791
    - Colonial period 1792 – 1924
    - Industrial period 1924 – 1986
    - Modern period 1986 – Present

The precolonial period brought forth a period of change to the landscape itself as Aruba went from an uninhabited landscape to one being continuously exploited for its marine and terrestrial resources, with an increase in the landscape manipulation when the indigenous people began conducting agricultural activities (Versteeg, 1976; Boerstra, 1982; Versteeg and Ruiz, 1995; Dijkhoff and Linville, 2004, p. 5; Kelly and Hofman, 2019, p. 148)

The Historic period was a turning point in the history of Aruba, more specifically when the Spanish "discovered" the island. The Spanish deported as many indigenous people as they could catch to Hispaniola (Hartog, 1961). Afterwards, the island was sparsely inhabited by indigenous people and occasionally visited by the Spaniards (Alofs and Dalhuisen, 1997). The Dutch West India Company took over in 1636 and used the island to raise cattle, goats, pigs, sheep, and horses (Teenstra, 1836; Hartog, 1953). After the Dutch West India Company went bankrupt, the island of Aruba went through a period of war and hardships between 1792 – 1816 which in turn depleted the resources on the island (Menkman, 1942, p. 188; Hartog, 1953, p. 75, 1961; Bosch, 1985; Martis, 2018) After 1816, the island regained more stability through the agro-mercantile industry, gold mining, and phosphate winning (Hartog, 1953; Alofs and Merkies, 1990, 2001).

The Industrial period brought with it the Second World War. However, Aruba benefitted during this period through the oil industry. Aruba had two oil companies, namely the Lago Oil Transport Company and the N.V. Arend Petroleum Maatschappij (Alofs and Merkies, 2001; Historia di Aruba: http://www.historiadiaruba.aw/index.php?option=com_content&task=view&id=28&Itemid=42; Ridderstaat, 2007, Dijkhoff, 2021). Coastal developments was prominent during this period with the consutrction and expansion of harbors located at Oranjestad and San Nicolaas (Lago Oil and Transport Co. Ltd: https://lago-colony.com/; Awe Mainta, 2021).

3. Risk assessment

Natural impact

The underwater archaeological resources of Aruba are affected by mechanical, biological, and chemical threats. The mechanical threats are climate change, hurricanes, and tropical storms. Climate change is causing an increase in the sea level rise which in turn increases coastal erosion, therefore putting the precolonial settlements, historic harbors, and coastal constructions at risk (Symister and Dijkhoff, 2022, p. 40). Hurricanes and tropical storms are more commonly occurring natural disasters. However, due to the position of Aruba, they rarely directly affect the island (Scheffers, 2004, p. 164). The island is impacted through an increase in wind, rain, and rougher sea conditions. This in turn causes flooding which erode the coastline and displaces archaeological materials situated underwater, and the rough seas caused and causes ships to lose control, capsize, lose their anchors, sink, or wash ashore (Scheffers, 2002, 2004; Scheffers et al., 2009; Meteorological Department Curacao, 2013; Diaro, 2020; Dijkhoff, 2021).

The biological threat factors affecting the underwater archaeological resources are both aerobic and anaerobic as sewage water are being introduced to the ocean creating anoxic environments (Vermeij *et al*., 2020, p. 33), namely marine borers, cyanobacteria, anerobic erosion bacteria, and wood degrading bacteria (Manders, 2017, p. 83-84; Ridwan, 2015, p. 19). These biological deterioration processes are continuous and can be slowed down but not stopped completely. The chemical threat factors entails the metal erosion of the underwater archaeological resources made of metal materials. When metal is exposed to oxygen, it starts to corrode, and the more oxygen present, the higher the corrosion (Ridwan, 2015, p. 19). The material analysis and desk-based assessment of the shipwrecks revealed that the underwater archaeological resources are made out of a variety of metals, which in turn are undergoing varying degrees of deterioration. Metal erosion is a continuous process that can be mitigated against and slowed down but cannot be stopped completely.

Human impact

As the population of Aruba began expanding, so did the need for more imported goods and the size of ships coming and going to the island, in addition to the importance of tourism.

Dredging began in the early 1900's as the size of the ships began expanding. Dredging occurred at Paardenbaai, Oranjestad starting from 1916 to 1948 and the sand was used to create a strip of 75 meters wide where construction was built upon it (Awe Mainta, 2021). Port expansion at San Nicolaas entailed dredging and underwater blasting in order to make the port more accessible and to build berths during the 1930's and 1960's (Historia di Aruba: http://www.historiadiaruba.aw/index.php?option=com_content&task=view&id=28&Itemid=42; Eakin *et al*., 1993, p. 140, 142). As last, dredging occurred at Barcadera between 2018 – 2022, and the sand extracted was used for land reclamation (Dijkhoff, 2023, p. 49-50).

Aruba relies heavily on the maritime and underwater environment, namely through tourism, fishing, and trading. The amount of tourism has been steadily increasing (Luksenburg and Parsons, 2014, p. 136) on Aruba which in turn increases the visits made to the underwater archaeological resources that serve as dive and snorkel sites. However, an increase of visits can also increase the extent of damage, looting, and treasure hunting that occurs. In addition, the dive sites are beneficial locations for fishing as marine organisms tend to cluster around the ship-, and airplane wrecks. However, the fishing methods employed by the fishermen tend to be destructive, namely they tend to anchor directly on the ship and airplane wrecks. In addition, the degree of fishing and tourist activity seem to tie in together, more tourism on the island can result in more consumption of fish and shellfish in turn leading to more fishing activities.

The economic benefits of tourism and fishing led to pressure being put on the underwater archaeological resources from a socio-political stand point. This in combination with a lack of awareness, knowledge, and experience leads to the destruction of potential underwater archaeological remains.

4. Cultural valuation of the underwater cultural heritage

4.1. Aesthetic value

All seventeen known underwater archaeological resources are visible within the landscape. However, the precolonial settlements are visible if the individuals know what they are looking for as the archaeological remains entail varying sizes of stones, pottery, shells, and coral that blend in within the landscape. Three of the known underwater archaeological resources, and fourteen future underwater archaeological resources are currently in use as dive and snorkel locations (see attachment …).

4.2. Historic value

The precolonial settlements portray the beginning of the habitation period of Aruba, and therefore forms part of the collective memory the local communities holds for the indigenous period. Of the six shipwrecks, the four shipwrecks dating back to World War II are heavily remembered within the local communities as this was a time of war and this was when the island was attacked.

4.3. State of preservation

The precolonial settlement contains pottery, stones, corals, and shells which are durable materials within the landscape. However, due to their location within the landscape, namely situated on the sand covered limestone, it is undergoing continuous wind, rain, and coastal erosion that in turn is eroding the archaeological materials and leading the artefacts to fall into the ocean.

The archaeological artefacts present at Spaans Lagoen and Commandeursbaai harbor, namely the metal artefacts, which were anchors, cannons, car wrecks, construction materials, fishing materials, industrial materials, military remnants, platforms, propellors, and shipwrecks and shipwreck remnants are undergoing varying degrees of metal corrosion. In addition, the distribution of materials, namely the anchors, ballast stones, bottles, cannons, fishing and military materials, propellors, and shipwreck remnants are susceptible to being looted.
The metal ship remnants of the unknown shipwreck situated on the windward side of the island are undergoing metal corrosion, in addition to being affected by the rougher sea conditions, hurricanes and tropical storms activities. What is left of the English steamship the Californian are namely metal ship remnants that are undergoing a continuous mechanical threats, namely hurricanes and tropical storms activities and metal corrosion. If biological materials are still present, these archaeological artefacts would be undergoing continuous biological deterioration.

In addition, it is susceptible to looting by the fishers and divers who are qualified to reach and exploit this shipwreck. The shipwrecks dating back to World War II were made out of steel and metal materials, in addition to containing wood, metal, glass, and plastic artefacts. The shipwrecks and subsequent artefacts on board are therefore undergoing mechanical, biological, chemical, and human threats and deterioration.

4.4. Quality of archaeological information

Representative value

The Archaic period settlements represents the locations that were exploited for a variety of activities. It can therefore give information on how the site was used and why this region was chosen. In the case of the Archaic period settlements, the sites portray the nomadic lifestyle of the individuals, where they exploited the shorelines for the consumption of fish and shellfish, and these were temporary settlements where they stayed for periods at a time.

The Ceramic period sites represents the catchment areas that were exploited for the harvesting and processing of the fish and shellfish. These sites give insight into the continuous importance of marine food sources for the indigenous people living during the Ceramic period on Aruba, that were beginning to conduct agricultural activities.

The harbors of Spaans Lagoen and Commandeursbaai portray activities starting from the precolonial period up until modern times. These harbors represent a chronological timeframe of usage over the entire habitation history due to the fact that these regions provide easy accessibility to the island. These regions were used by the indigenous people as locations to enter and exploit the island, followed by Commandeursbaai becoming the main harbor up until the 18th century where the focus was switched to Oranjestad.

The shipwrecks that sank during World War II, namely the SS Arkansas, SS Oranjestad, SS Pedernales, and SS Antilla portray a time where the island of Aruba had significant meaning in providing oil to the British, the Dutch, and the Americans during a period of war. This gives information regarding the type of vessels that sailed to the island and from where, the sailing routes they took and where the vessels anchored, and why this region was used as an anchorage.

Significance information

The underwater archaeological sites and resources have an aesthetic, cultural-historical, and economic value. All, with the exception of one underwater site, all the known and future underwater archaeological resources are situated on the leeward side of the island and are accessible to everyone to visit and see through kayaking, diving, snorkeling, or fishing activities. This in turn makes them valuable to the communities as they form part touristic economic gain.

In addition, the underwater archaeological sites and resources portray a chronological history of how the waterways and the sea surrounding Aruba was used throughout time. All the underwater archaeological resources have historical value as each site portrays a time period that gives information regarding the habitation history and the trade that occurred.

4.5. Conclusion

All the seventeen known underwater archaeological resources, in addition to the future underwater archaeological resources have an aesthetic, cultural-historical, and economic value, which makes them (future) underwater cultural heritage. The sites situated underwater are for the most part visible and easily accessible and can therefore be exploited for diving, snorkeling, and fishing activities. However, the underwater sites are undergoing continuous and varying extent of mechanical, chemical, biological, and human threats and deterioration.

5. Site management

5.1. Cost-benefit analysis and general conclusion

It is recommended that the underwater archaeological resources be left in-situ, but be legally documented as a heritage site and put under a legal protection association. The in-situ preservation should entail continuous monitoring and site assessments once a year as this is cost effective. By doing this, a continuous overview will be had on the archaeological remains present and the locations thereof. This makes it possible for researchers to study whether archaeological artefacts were displaced, are eroding away, or are now missing.

5.2 Site management agenda

Safeguarding

The underwater archaeological resources could be protected, mitigated against, or the deterioration processes could be slowed down through legal measures and physical protection. However, no laws and legislations nor physical protection are in place regarding the management and protection of the underwater sites. This is pending the ratification of the 2001 UNESCO convention.

Monitoring, visualizing, and financing

The steps for the efficient management of the underwater cultural heritage of Aruba are portrayed in table … . Site assessments should be conducted on the known underwater cultural heritage once a year by a marine and underwater archaeologist and their accompanying dive team, consisting of a safety diver, a dive team leader, and advanced divers. The underwater sites will be documented, photographed, and drawn.

Discussion

A database was created for this thesis report in order to create an overview of what is known and considered underwater cultural heritage to the government, local businesses, and the local communities of Aruba through its aesthetic, cultural-historical, and economic value in preparation for the ratification of the 2001 UNESCO convention. However, why should the 2001 UNESCO convention be ratified on Aruba and why is this database necessary?

The 2001 UNESCO convention supplies protection, research, education, heritage access, and international cooperation to ensure the protection of the underwater archaeological resources. Aruba currently lacks sustainable national cultural policies or legislations in regards to the protection of the underwater cultural heritage (Aruba Today, 2020). This is problematic to the underwater archaeological resources as a majority currently functions as dive and snorkel locations, which leaves them susceptible to damage. In addition, no protective measures are in place meaning that the underwater archaeological resources remain underwater with no mitigation measures being implemented to slow down the deterioration. Thus, ratification is needed in order to create sustainable tourism opportunities, new jobs for the local communities, and promote the culture on the island.

The database created for this thesis report needs a long term sustainable underwater cultural heritage management plan in combination with definitive laws and legislations and the establishment of the underwater archaeological resources as underwater cultural heritage protected by law in order to be useful in the preservation thereof. It is currently just an overview of information regarding the underwater archaeological resources. However, by implementing the above mentioned steps, it can become a useful database accessible for the entire island in the management in the underwater cultural heritage.

Conclusion

The aim of this thesis was to present how the archaeological underwater cultural heritage that date back to the Archaic, Ceramic, and Historic periods can be managed and preserved. The underwater cultural heritage were assessed, in addition to the significance and threat factors thereof. In order to analyze the archaeological underwater cultural heritage, research questions were formulated within this study. This chapter addresses the research questions presented at the beginning of this thesis research.

Research questions

What is the level of significance of the archaeological underwater cultural heritage for the different stakeholders present on Aruba?

The significance assessment of the underwater cultural heritage was divided into four stakeholders sectors, namely the government, non-government, business, and local stakeholders. The government stakeholders are responsible for managing the underwater cultural heritage through funding, legislation, capacitation, control and enforcement, spreading awareness, educating, and cooperation with the local communities and businesses. At minimum a portion of the underwater cultural heritage are attractive to tourists. Tourism in turn is one of the largest sources of income for the island. Thus, Aruba's underwater cultural heritage is important to the government stakeholders as it holds economic and cultural value. The non-government stakeholders sees Aruba's underwater cultural heritage as part of the island's history and culture that should be kept alive for generations to come. Non-government stakeholders therefore have a moral, ethical, and cultural involvement in regard to the management of the underwater archaeological resources. Due to the fact that the underwater cultural heritage brings in large economic gain to the island, it is of high significance to the local businesses of Aruba. Despite a lack of basic knowledge in regard to what underwater cultural heritage entails from the local communities, they have knowledge of what is present underwater due to the popularity of the dive/tourist sites and sees these sites as a part of Aruba's cultural history as they also enjoy and exploit these resources. When informed that these sites are threatened, they show a need and want to protect it for future generations.

What are the archaeological underwater cultural heritage of Aruba?

The archaeological underwater cultural heritage is divided into three categories, namely known, unknown, and future resources spanning between three time periods, namely the Archaic (1500 BC – 900/1000 AD), Ceramic (900/1000 AD – 1515 AD), and the Historic period (1515 – 1973).

Aruba has a total of seventeen known archaeological underwater cultural heritage sites divided among the Archaic, Ceramic, and Historic periods. Seven of the seventeen sites were identified as precolonial settlements containing varying densities of shells, shell fragments, stones, corals, pottery, and pottery fragments. The underwater sites dating back to the Archaic period are all located in the northwestern region, namely at *Arashi* and *Palm Beach*, while the underwater sites dating back to the Ceramic period are more spread out with sites found and documented in the northwest of *Palm Beach* and west of *Mangel Halto*. However, the northwestern region was exploited throughout the entire precolonial period as three submerged precolonial sites were identified in the *Malmok salina* which could not be determined whether it was activities from the Archaic or Ceramic period. The underwater sites dating back to the Historic period were identified as two harbors, six shipwrecks, and one religious symbol. Fifteen future underwater sites were located on the leeward side with one underwater site present at the eastern tip of the island at the windward side. The two harbors, *Paardenbaai* and *Commandeursbaai* contain 27 known individual sites. The materials found at *Spaans Lagoen* were namely construction and industrial materials, fishing traps, a floating platform, a fiber boat shipwreck, anchor, bottles, ballast stones, a possible cannon, and concrete wood. The artifacts at *Commandeursbaai* were bottles, remains of old harbor buoys, a military helmet, a leather shoe, remains of fiber boats, an admiralty stock anchors, a possible car wreck, the blade of a propeller, and a ballast stone. The artifacts date back to a period between the 17th and 20th centuries, indicating that long term activities took place at this region of the island. The shipwrecks found were namely one English steamship that wrecked at the northside of the island, one cargo ship that sank due to World War II activities, three oil tankers that were attacked in 1942 and (partially) sank at the northwest and east side of the island and one unknown ship that sank at the eastern tip of the island.

The unknown underwater cultural heritage was speculated based on the maritime landscape using historical maps, photographs, and sources, in addition to archaeological evidence namely known underwater cultural heritage. Given the location of the known Archaic period underwater archaeological resources and the diet and the way of life, it could be speculated that the leeward side of the island still has potential underwater archaeological resources, more specifically the region between *Arashi* and *Palm Beach* and *Spaans Lagoen*.

The way of life for the individuals who lived during the Ceramic period changed. However, the resources on the island were still being exploited, namely fish and shellfish. This was analyzed based on the catchment areas, the knowledge of the maritime landscape and the archaeological evidence, namely the fact that the known underwater sites are in close proximity to two settlements, namely *Oranjestad* and *Savaneta*. Therefore, it could be speculated that the region between *Arashi* and *Oranjestad* could contain potential underwater archaeological resources, in addition to the region between *Mangel Halto* and *Commandeursbaai*. The Historic period was divided into four categories, namely the Spanish, Dutch West India Company, Colonial, and Industrial periods. The Spaniards used the island for its beneficial location in the trade industry, where new plant species and animals were introduced on the island, in addition to the exportation of wood from the island itself. However, indigenous people did still live on the island, namely at *Savaneta*, *Piedra Plat* and *Noord*. Given the historical background and the maritime landscape of the *Commandeursbaai*, it is speculated that this harbor was used during the 16th and 17th centuries in turn leaving possible underwater cultural heritage behind that have yet to be discovered. The island continued to be sparsely inhabited during the period of the Dutch West India Company. However, the island did continue to export products, with an important one being salt. During the 17th and 18th centuries, salt was harvested off the coast of *Rodger's beach*. To access this region from the ocean, vessels had to enter through *Commandeursbaai*. However, this region was only accessible by small and flat vessels, making larger vessels vulnerable to stranding and/or wrecking. Based on the maritime characteristics and usage history, the region between *Commandeursbaai* and *Rodgers beach* could be valued at minimum to possibly contain archaeological materials from this time period. In addition, the calm shallow waters between *Arashi* and *Eagle beach* was used to anchor ships. Therefore, this region also has a potentially high chance of containing archaeological materials. The northeast side of the island, namely the bay at *Alto Vista*, was visited throughout this period due to the water well situated here. The focus turned from *Commandeursbaai* to *Paardenbaai*, *Oranjestad* during the Colonial period. The years between 1792 – 1816 brought forth confusion, war, and the depletion of the island's resources as the island continuously changed hands. Multiple battles took place at *Paardenbaai* until 1806, which led to the built of the fortification called *Fort Zoutman*. In addition, *Paardenbaai* became the trading centre for Aruba as this harbor had better accessibility for ships. Given the extensive activities that took place during this period at *Paardenbaai*, remnants could have been left behind. After the years of difficulty, the island had two periods of prosperity through gold mining and phosphate winning. Gold mining occurred at the north side at *Bushiribana* near rough waters and then moved to *Balashi* on the west side of the island with calmer waters.

Lastly, the hostile water environment on the windward side was possibly used as a sailing route as historical sources documented one warship and two cargo ships between the north tip and *Andicuri*. This is built upon by the presence of the gold mining at *Bushiribana* and the popular water well situated at *Alto Vista*. Therefore, possible archaeological remains, namely ship materials and anchors, could be present. The industrial period is known for the oil industry in which the harbors of *Paardenbaai* and *San Nicolaas* (including *Rodger's beach*) were used. This was due to the fact that the two oil refineries in Aruba were situated at *San Nicolaas* and *Oranjestad*. Both locations were used for anchorage and both underwent construction work. Docks were built and the harbors were expanded and deepened. Therefore, industrial and construction materials, ship materials, and personal items can be present at these locations. However, the deepening activities that took place lowered the chances of archaeological materials being present.

A total of fifteen underwater archaeological resources are considered to be future archaeological underwater cultural heritage when they become older than 50 years, due to the fact that they are historically, aesthetically, and economically valued by the government, local businesses, and the local communities. The future underwater sites were sunk between 1976 – 2015 and are all situated on the leeward side of the island. The known underwater archaeological resources are twelve shipwrecks, four airplane wrecks, and household furniture.

What are the threat factors affecting the archaeological underwater cultural heritage of Aruba?

The island of Aruba has a semi-arid tropical marine climate with relatively equal temperatures all year round. The northeast and eastern side of the island is dominated by strong winds and currents creating heavy surf conditions. Steady longshore currents are present at the southern tip of the island, and the westside has calm waters with a barrier reef of ca. 366 meters extending along the entire western and southwestern coast. Aruba's underwater archaeological resources are situated in different ecosystems and marine habitats. The leeward coast consists of sandy beaches with intermixed habitats with different species of seagrass growing in varying densities spanning from sparse to dense, with the majority growing in the northwest region of the island. The environment between the coast and the barrier reef on the west side of the island consists of multiple complex soft bottom habitats where the region is covered in sparse to dense seagrass.

The landscape characteristics and usage, natural disasters, climatic, socio-political, economic, and managerial factors play a role in the current preservation status of the underwater archaeological resources and materials. Three tsunami events occurred during the precolonial period which impacted the windward side of the island at 1500 BC, 450 AD, and 1450 – 1550 AD.

Therefore, there is a high probability that precolonial sites on the upper layer of the limestone situated on the windward side were (partially) destroyed. Archival documentations revealed that historical hurricanes caused rough waters which led to vessels losing their anchors, capsizing and sinking or were pushed ashore. In addition, recent hurricane events caused heavy surf conditions and flooding with waves reaching heights between three to six meters hitting the northern, northwestern, and southwestern coastlines. The high waves and flooding in turn can cause up spits of debris indicating that the archaeological materials were in part disrupted. If severe enough, entire frameworks can be displaced as was the case with Baboo during hurricane *Lenny* in 1999. Tropical storms caused similar damage to the island, namely flooding and rough currents. The tropical storms impacted the west and southside of the island which in turn could have displaced materials from the known, potential, and future underwater archaeological resources.

The underwater archaeological resources containing wood or stone artefacts are undergoing anaerobic and aerobic biological deterioration. The known and future underwater sites situated within the anoxic environment are affected by cyanobacteria and aerobic erosion bacteria. However, these are slow deterioration processes. The underwater sites containing wood materials situated in the aerobic environment are susceptible to wood degrading bacteria and shipworms. However, the extent and which biological organisms are affecting the underwater archaeological resources are unknown. The known shipwrecks and future underwater archaeological ship-, and airplane wrecks are undergoing metal corrosion. However, this process is slowed down by the anoxic environments and the artificial reefs creating a protective layer of concretions. Smaller iron objects are undergoing faster metal corrosion than copper objects.

The known and future underwater archaeological resources present an important economic factor to the island through fishing and diving/snorkeling activities. However, this can also affect the underwater archaeological resources in a negative way. Looting and treasure hunting on Aruba's underwater archaeological resources is a problematic occurrence as valuable information is being taken away from its original environmental context and therefore a part of the story is now lost. Fishing is an important source of income for the locals, and the underwater archaeological resources are ideal locations for fishing as fish are attracted to artificial reefs and tend to cluster in these regions. However, the fishing methods tend to be intrusive as the fishermen anchor on the underwater sites. This can cause pieces of the site to break off. The longer a site is underwater, the more extensive the damage becomes, with the SS Antilla and SS Pedernales portraying the most damage. The future underwater archaeological resources are becoming beneficial locations where fish tend to form clusters which in turn can switch the focus to the underwater sites situated between the *Renaissance island* and *Sero Colorado*, making them susceptible to breakage.

In addition, tourism is linked to the fishing activities. As tourism grows so will the need for the consumption of fish and shellfish which will increase the fishing activities taking place. Dredging occurred at *Paardenbaai*, *Barcadera*, and *San Nicolaas* between 1916 – 2022 in order to make the harbor more accessible for larger vessels. The sand was then used for land reclamation and construction work.

Thus, the potential archaeological materials were taken out of their environmental context and were either destroyed, lost or now resides under buildings. As the economy expanded, pressure to continue developing the island arose. However, the fact that potential underwater archaeological resources can be present during the built of new piers and hotels were not taken into consideration. In addition, the lack of awareness, lack of policies and legislations, and the priority for economic gain can lead to inexperienced tourists and locals diving to the underwater sites and subsequently causing damage.

Why is it important to actively manage Aruba's archaeological underwater cultural heritage?

It is important to actively manage Aruba's underwater cultural heritage as this is part of the history and culture, in addition to portraying how the island came to be. When Aruba's underwater cultural heritage is actively being managed, the community is simultaneously being informed about the presence and preservation status of the archaeological underwater cultural heritage giving them a sense of understanding. When the underwater cultural heritage is understood, it is in turn valued and a need to protect it is created. When it is protected, it can be enjoyed for generations to come. However, Aruba's archaeological underwater cultural heritage are continuously undergoing damage from hurricanes, tropical storms, chemical corrosion, biological deterioration, damage by people through fishing, diving/snorkeling, construction activities, a lack of awareness, and lack of laws and regulations.

In-situ preservation is recommended as the first option as the known and future underwater sites are beneficial for the ecological environment by forming artificial reefs which houses an abundance of marine organisms and fish species. This in turn is beneficial for the economy of Aruba as these underwater sites became popular fishing and dive/snorkel locations. In addition, the known and future underwater archaeological resources situated in an anoxic environment are undergoing a slowed down chemical and biological deterioration. Therefore, immediate action is not needed.

However, at the same time known and future underwater archaeological resources are situated in an aerobic environment which makes them susceptible to rapid biological and chemical deterioration due to being exposed to oxygen. Therefore, it is important to actively manage and monitor the sites situated in both the anoxic and the aerobic environment to document the degree of deterioration in relation to time. If the degree of deterioration is threatening to destroy the archaeological materials, they should be photographed, the location documented and then lifted by archaeological professionals to preserve ex-situ in the National Archaeological Museum of Aruba. In addition, during hurricane and tropical storm events, archaeological materials can be pushed ashore. Therefore, after these events, surveys must be conducted by archaeological professionals to gather the potential archaeological materials that came ashore to ensure that regardless of the fact that they no longer reside in their original context, the information is not lost. The information is not lost, it gives researchers the opportunity to analyse and present these stories and objects within the National Archaeological Museum Aruba.

Main question

How can Aruba's archaeological underwater cultural heritage sites be managed?

Aruba has a total of seventeen underwater sites that are considered underwater cultural heritage that range from precolonial settlements that are situated at *Malmok*, *Arashi*, *Palm Beach* and *Mangel Halto*, six historic shipwrecks, one religious symbol, and two harbors located at *Commandeursbaai*, *Spaans Lagoen*, from the northern tip all the way down to *Eagle beach* and at *Sero Colorado*. The known underwater cultural heritage is undergoing different threat factors to varying degrees based on their locations and material type. The precolonial sites were settlements that date back to the Archaic and Ceramic periods containing shells, pottery, stones, and coral artefacts. These settlements were originally terrestrial but due to continuous wind and coastal erosions they are now falling into the ocean. The continuous erosion of the maritime sites could therefore be mitigated against by adding a new layer of sand on the settlements in addition to implementing geotextiles.

The historic underwater sites are six shipwrecks, two harbors and one religious symbol. All the known underwater cultural heritage sites are being affected by hurricane and tropical storms events that hit the entire island from different angles. In addition, the shipwrecks SS Antilla, SS Pedernales and SS Arkansas are situated in an anoxic environment, in addition to the harbor *Commandeursbaai*. Thus, they are undergoing slow chemical and biological deterioration. However, the shipwrecks SS Oranjestad, the Californian, the unknown shipwreck at *Sero Colorado*, the cross of iron pipes, and

the harbor at *Spaans Lagoen* are situated within an aerobic environment which makes them susceptible to aerobic chemical and biological deterioration.

Sandbags or debris nets could be placed on the Californian, the unknown shipwreck at *Sero Colorado*, SS Oranjestad, SS Arkansas, and the sites located at the harbors of *Commandeursbaai* and *Spaans Lagoen* as this helps create an anoxic environment and reduce erosion.

The known shipwrecks of SS Antilla and SS Pedernales have undergone extensive damage from the intrusive fishing methods, namely fishermen anchor on the shipwreck sites. This can be mitigated against by implementing mooring lines which lets the fishermen continue to exploit the area but reduces the damage being done to the shipwrecks, In addition, the known underwater cultural heritage have become popular dive sites, namely the Californian and the unknown shipwreck at *Sero Colorado* (for experienced divers), SS Antilla, SS Pedernales, SS Arkansas, and the sites situated at *Spaans Lagoen* and *Commandeursbaai* (for local divers). This can be mitigated against by implementing barrier methods, namely metal barriers. However, given the size and depth of the SS Antilla and SS Pedernales, first stricter guidelines and laws should be implemented, if this does not work then metal barriers can be discussed.

However, the most important aspects of managing Aruba's underwater is to continuously monitor and document all the known underwater cultural heritage sites for changes occurring on site itself, in the environment, and the materials. In addition, implementing an educational program island wide is crucial as there is a lack of knowledge regarding the presence, threat factors, and preservation status of the underwater cultural heritage.

These mitigation methods can only be implemented when definitive laws and legislation enforcing the protection and management of the underwater cultural heritage are in place. In addition, to having a basis of the the value and role the stakeholders will play in the management of the underwater cultural heritage. In order to effectively manage Aruba's underwater cultural heritage, a good balance is needed between the significance, the stakeholders, budget, historical, economic, and aesthetic value and enjoyment in order to make good mitigation decisions.

Limitations and recommendations

Limitations within this study

Environmental information and threat factors

The extent of the metal corrosion occurring on the known, unknown, and future underwater archaeological resources are not known due to the fact that field analysis was not conducted to analyze the level of oxygen present in the underwater environment and the degree of metal corrosion occurring on the metal archaeological objects. The degree of corrosion or whether metal corrosion was occurring was examined based on photographs and one small macroscopic material analysis of the shipwreck SS Pedernales. A macroscopic analysis, also known as visual analysis, can be highly subjective, where the same photographic and material assemblage can yield different results. In addition, in relation to the lack of data on the oxygen levels in the surrounding waters of Aruba, the known, unknown, and future underwater archaeological resources are being affected by biological threat factors, namely aerobic and anaerobic bacteria. It was established that the distribution of sewage water was creating an anoxic environment, most prominently in the northwestern region. However, the oxygen composition and which biological organisms are present affecting the resources are unknown due to the lack of in field research.

Recommendations

The following recommendations for future research are presented here based on the results and limitations of this study. The first recommendation for future research would be to conduct an in depth chemical and biological analysis on the archaeological materials situated underwater in order to determine the exact state of preservation of the metal and wood artefacts. The chemical analysis consists of the following steps, namely sampling, field sample pretreatment, laboratory treatment, laboratory assay, calculations, and results. Portions of the bulk metal materials must be removed, treated, and analyzed to determine the construction of the metal alloys and the deterioration status. The biological deterioration of the wood artefacts need to be determined based on the following information, that in turn needs to be scientifically established through extensive in field research, namely the level of oxygen present in the underwater environment and the temperature of the water which in turn determines the organisms that live in the environment.

The chemical and biological scientific research to determine or speculate the preservation of the underwater cultural heritage is needed to determine which mitigation measures needs to be taken to prevent the mechanical threats affecting the underwater archaeological resources. This was not the main focus within this thesis report as more research is needed.

Bibliography

Alofs, L., Merkies, L. (1990). Ken ta Arubiano. Sociale Integratie en Natievorming op Aruba. *Antillen Working Papers* 15.

Alofs, L. (1996). *Slaven zonder plantage. Slavernij en emancipatie op Aruba, 1750 – 1863.* Charuba.

Alofs, L., Dalhuisen, L. (1997). *Geschiedenis van de Antillen: Aruba, Bonaire, Curacou, Saba, Sint Eustastius, Sint Maarten.* Walburg Press.

Alofs, L., Merkies, L. (2001). *Ken ta Arubiano? Sociale integratie en natievorming op Aruba, 1924-2001.* VAD/De Wit Stores.

Alofs, L. (2018). *Koloniale mythen en benedenwindse feiten. Curacao, Aruba en Bonaire in inheems Atlantisch perspectief, ca. 1499 – 1636.* Sidestone Press.

Amigoe (1977). *Tecla treft Curacao.* Publication: Amigoe, 23-09-1977.

Angela, H. (2001). *Verslag: Onderwater survey, Commandeursbaai.* Verslag Wetenschappelijke Afdeling Archeologisch Museum, Aruba.

Antczak, A. T., Haviser, J. B., Hoogland, M. L. P., Boomert, A., Dijkhoff, R. A. C. F., Kelly, H. J., Magdalena-Antczak, Ma., Hofman, C. L. (2018). Early horticulturalists of the southern Caribbean. In B. Reid (Ed), *The Archaeology of Caribbean and Circum-Caribbean Farmers (6000 BC – AD 1500)* (pp. 113-146). Routledge.

Appiah, A. (1994). Race, Culture, Identity: Misunderstood Connections. *The Tanner Lectures on Human Values.*

Aruba Today. (2020). *Heritage, an enabler of Sustainable Development.* Publication: Aruba Today, 08-01-2020.

Awe Mainta. (2021). *Aniversario di un dia historico di Paardenbaai.* Publication: Awe Mainta, 07-04-2021, 1-45.

Bakker, M. M., Klooster, O. E. I. van der. (2008). Cultuurhistorische Verkenning van het Schelpstraatkwartier en het Koopliedenkwartier in Oranjestad. *Overzeese architectuur Rapport, 2008.*

Boerstra, E. H. J. (1982). *De Precolombiaanse Bewoners van Aruba, Curacou en Bonaire.* De Walburg Pers.

Borges, L. M. S. (2014). Biodegradation of wood exposed in the marine environment: Evaluation of the hazard posed by marine wood-borers in fifteen European sites. *International Biodeterioration and Biodegradation* 96, 97-104.

Bosch, G. B. (1985). *Reizen in West-Indie; deel I en II (1829 – 1836).* S. Emmerling.

Colijn, E. O., Beentjes, K. K., Butot, R., Miller, J. A., Smit, J. T., de Winter, A. J., van der Hoorn, B. (2019). A catalogue of the Coleoptera of the Dutch Antilles. *Tijdschrift voor Entomologie* 162, 67-186.

Colombini, M. P., Lucejko, J. J., Modugno, F., Orlandi, M., Tolppa, E. L., Zoia, L. (2009). A multi-analytical study of degradation of lignin in archaeological waterlogged wood. *Talanta* 80, 61-70.

Copper Development Association. (2012). *Copper Alloys for Marine Environments.* Publication: Copper Development Association.

Da Silva, A. R., Villegas, T. (2021). Unit I. The UNESCO 2001 convention on the Underwater Cultural Heritage. In M. R. Manders and C. J. Underwood (Eds), *The UNESCO Training Manual for the Protection of the Underwater Cultural Heritage in Latin America and the Caribbean.* United Nations Educational Scientific and Cultural Organization (UNESCO), Cultural Heritage Agency of the Netherlands (RCE).

Demaison, G. J., Moore, G. T. (1980). Anoxic environments and oil source bed genesis. *Organic Geochemistry* 2 (1), 9-31.

Derix, R. R. W. M. (2016). *The History of resource exploitation in Aruba.* Paper in series "Spatial Developments in the Aruban Landscape: A multidisciplinary GIS-based approach derived from geological, historic, economic, and housing information".

Diario (2020). *143 aña pasa Horcan Tecla a impacta e isla nan ABC.* Publication: Diario, 24-09-2020.

Dijkhoff, R. A. C. F., Linville, M. S. (2004). Aruba, "Island of shells". In R. A. C. F. Dijkhoff and M. Linville (Eds), *The Archaeology of Aruba*: *The marine shell heritage* (pp. 1-8). The Archaeological Museum of Aruba.

Dijkhoff, R. A. C. F. (2004). The History of Archaeological Research in Aruba. In R. A. C. F. Dijkhoff and M. Linville (Eds), *The Archaeology of Aruba: The marine shell heritage* (pp. 35-51). The Archaeological Museum of Aruba.

Dijkhoff, R. A. C. F., Kelly, H. J., Croes, F., Angela, G. H. (2010). *Preliminary Report of the Artifacts of Old Oranjestad Found on the 22nd and 23rd of February 2010.* Intern Rapport 21, National Archaeological Museum Aruba.

Dijkhoff, R. A. C. F. (2011a). *Towards a Sustainable Underwater Cultural Heritage Management in Aruba.* Paper presented at the Reunión Subregional Sobre la Convención del la UNESCO para la Protección del Patrimonio Cultural Subacuatico – Desafíos Técnicos y legales del Patrimonio Subacuatico en México, Centro América y el Caribe, Cozumel, México.

Dijkhoff, R. A. C. F. (2011b). *Towards a Sustainable Underwater Cultural Heritage Management in Aruba.* Paper presented at the UNESCO Caribbean Meeting on the Protection of the Underwater Cultural Heritage, Kingston, Jamaica.

Dijkhoff, R. A. C. F., Kelly, H. J., Croes, F., Angela, G. H. J. (2012). A Sailor's Grave at Boc'I Brik/Puente: Skeletal Remains of a Mariner of the German Brig Hero, Lost to the 1886 Hurricane Disaster. *Journal of the National Archaeological Museum Aruba* 2.

Dijkhoff, R. A. C. F., Linville, M. S. (2015). Achieving sustainable heritage management in Aruba. In C. L. Hofman and J. B. Haviser (Eds), *Managing our past into the future. Archaeological heritage management in the Dutch Caribbean* (pp. 71-87). Sidestone Press.

Dijkhoff, R. A. C. F. (2020). *Dutch Caribbean Maritime Heritage Workgroup.* Manuscript available at the National Archaeological Museum Aruba, Oranjestad, Aruba.

Dijkhoff, R. A. C. F. (2021). *Aruba/Dutch Kingdom 2022: Towards Ratification of the UNESCO 2001 Convention.* Paper presented at the UNESCO International Webinar/Seminar Overview of Underwater Cultural Heritage Management in Latin America and the Caribbean, Habana, Quito, Bogota.

Dijkhoff, R. A. C. F. (2021). *Onderwater Cultureel Erfgoed Sites Aruba. Werkdocument MANA in het kader van ratificeren door Koninkrijk der Nederlandsen van UNESCO Conventie 2001: Bescherming van Onderwater Cultureel Erfgoed, Aruba.* Manuscript available at the National Archaeological Museum Aruba, Oranjestad, Aruba.

Dijkhoff, R. A. C. F. (2022). *Aruba-Dutch Kingdom 2022 – Towards Ratification of the UNESCO 2001 Convention.* Paper presented at Ciclo di Charla "Hoyanan di Herencia Subacuatico na Aruba" organized by the National Archaeological Museum Aruba, Oranjestad.

Dijkhoff, R. A. C. F. (2023). *UCH Aruba Voorstel/Actieplan NAMA. Testcase: Project "Embeyecimento di Anker Cas Ariba".* Manuscript available at the National Archaeological Museum Aruba, Oranjestad, Aruba.

Eakin, C. M., Feingold, J. S., Glynn, P. W. (1993). Oil refinery impacts on coral reef communities in Aruba, N. A. *Global Aspects of Coral Reefs, Health Hazards, and History,* 139-145.

Frigerio, A. (2013). *The Underwater Cultural Heritage: a comparative Analysis of International Perspectives, Laws and Methods of Management* [Published PhD]. IMT Institute for Advanced Studies.

Gast, G. J., Jonkers, P. J., van Duyl, F. C., Bak, R. P. M. (1999). Bacteria, flagellates and nutrients in island fringing coral reef waters: influence of the ocean, the reef and eutrophication. *Bulletin of Marine Science* 65 (2), 523-538.

Hartog, J. (1953). *Aruba zoals het was, zoals het werd.* De Wit.

Hartog, J. (1961). *Aruba past and present, from the time of the Indians until today.* De Wit.

Hartog, J. (1996). *Het oude fort van Aruba. De geschiedenis van het Fort Zoutman en de Toren Willem III gedenkboek bij het tweehonderd-jarig bestaan van Fort Zoutman in 1996.* Koninklijke van Gorcum B.V.

Hartog, J. (1980). *Aruba zoals het was, zoals het werd. Van de tijd der Indianen tot op heden.* De Wit.

Haviser, J. B. (1991). *The First Bonaireans.* Report 10, Archaeological-Anthropological Institute of the Netherlands Antilles.

Heidecker, L., Siegel, M. I. (1969). Preliminary Report on the Excavation Henriquez-I Site, Tanki Flip, Aruba, Netherlands Antilles. *Florida Anthropologist* 22, 12-26.

Hochstuhl, W. C. (2001). *German U-boat 156 brought war to Aruba February 16, 1942.* Aruba Scholarship Foundation.

Houkes, M., Manders, M. R., Smit, B. I., Coenen, T. (2017). *Archaeologisch Vooronderzoek in de onderwaterarcheologie. KNA Leidraad Archeologie en Waterbodems.* Stichting Infrastructuur Kwaliteitsborging Bodembeheer.

Hupperetz, W. (2015). The cultural biography of a Street. Memory, Cultural Heritage and Historical Notion of the Visserstraat in Breda, the Netherlands (1200-2000). In J. Kolen, H. Renes, R. Hermans (Eds), *Landscape Biographies. Geographical, Historical and Archaeological Perspectives on the Production and Transmission of Landscapes.* Amsterdam University Press.

Kelly, H. (2012). Socio economic ties between Aruba and La Guaijra since the Pre-Colombian period. *Revista Jangwa Pana* 11, 49-63.

Kelly, H. Hofman, C. L. (2019). The Archaic Age of Aruba: New evidence on the first migrations to the island. In C. L. Hofman and A. T. Antczak (Eds), *Early settlers of the insular Caribbean. Dearchaizing the Archaic* (pp. 147-162). Sidestone Press.

Kersel, M. M., Luke, C. (2015). Civil Societies? Heritage Diplomacy and Neo-Imperialism. In L. Meskell (Ed), *Global Heritage: A Reader* (pp. 70 – 93). Wiley Blackwell.

Klooster, O. van der, Bakker, M., Bakker, M. M., Leven, J. van 't (2007). *Bouwen op de wind: architectuur en cultuur van Aruba.* Stichting Libri Antilliani.

Klooster, O. van der, Bakker, M. (2013). *Monumentengids Aruba.* Stichting LM Publishers.

Kim, Y. S., Singh, A. P. (2000). Micromorphological characteristics of wood biodegradation in wet environments: A review. *International Association of Wood Anatomists journal* 21 (2), 135-155.

Luksenburg, J. A., Parsons, E. C. M. (2014). Attitudes towards marine mammal conservation issues before the introduction of whale-watching: a case study in Aruba (southern Caribbean). *Aquatic conservation: marine and freshwater ecosystems* 24, 13—146.

MacLeod, I. D. (2016). In-situ Corrosion Measurements of WWII Shipwrecks in Chuuk Lagoon, Quantification of Decay Mechanisms and Rates of Deterioration. *Frontiers in Marine Science* 3 (38), 1-10.

Manders, M. R. (2017). Preserving a layered history of the Western Wadden Sea. Managing an underwater cultural heritage resource [Published thesis.]. Rijksdienst voor het Cultureel Erfgoed.

Manders, M. R. (2021). Unit 3. Management of Underwater Cultural Heritage. In M. R. Manders and C. J. Underwood (Eds), *The UNESCO Training Manual for the Protection of the Underwater Cultural Heritage in Latin America and the Caribbean.* United Nations Educational Scientific and Cultural Organization (UNESCO), Cultural Heritage Agency of the Netherlands (RCE).

Manders, M. R. (2021). Unit 4. The Underwater Archaeological Resources. In M. R. Manders and C. J. Underwood (Eds), *The UNESCO Training Manual for the Protection of the Underwater Cultural Heritage in Latin America and the Caribbean.* United Nations Educational Scientific and Cultural Organization (UNESCO), Cultural Heritage Agency of the Netherlands (RCE).

Martis, A. (2018). *De geschiedenis van Aruba tot 1816. Van zustereiland tot imperoim in imperio.* LM Publishers.

Menkman, W. R. (1942). *De Nederlanders in het Caraibisch Zeegebied. De Geschiedenis van de Nederlandse Antillen.* Van Kampen en zoon.

Meteorological Department Curaçao (2013). *Hurricanes and Tropical Storms in the Dutch Caribbean.* Publication: Meteorological Department Curaçao, 1-37.

Mickleburgh, H. L. (2013). *Reading the Dental Record. A Dental Anthropological Approach to Foodways, Health, and Disease, and Crafting in the pre-Colombian Caribbean* [Published doctoral dissertation]. Leiden University.

Nooren, K. (2008). Human impact on the vegetation of Aruba, Curaçao, and Bonaire. *Nieuwe West-Indische Gids* 40, 103-120.

Nooyen, R. H. (1962). *Historia di Alto Vista.* Curaçao.

Palm, J. de (1985). *Encyclopedie van de Nederlandse Antillen.* De Walburg Press.

Perasso, C. S., Antonelli, F., Calcinai, B., Casoli, E., Gravina, M. F., Ricci, S. (2022). The Bioerosion of Submerged Archaeological Artifacts in the Mediterranean Sea: An Overview. *Frontiers in Marine Science* 9 (888731), 1-25.

Ridderstaat, J. R. (2007). *The Lago story: The compelling story of an oil company on the island of Aruba.* Charuba.

Ridwan, N. N. H., Husrin, S., Kusumah, G. (2014). USAT Liberty Shipwreck Site in Tulamben, Karang Asem Regency, Bali is Under Threats. In H. van Tilburg, S. Walker, V. Vadillo, B. Fahy, J. Kimura (Eds), *Proceedings of The 2nd Asia-Pacific Regional Conference on Underwater Cultural Heritage* (pp. 881-892). Delta World Book.

Ridwan, N. N. H. (2015). Maritime Archaeology in Indonesia: Resources, threats, and current integrated research. *Journal of Indo-Pacific Archaeology* 36, 16-24.

Ruiz, A. C. (2004). The geography and geology of Aruba. In R. A. C. F. Dijkhoff and M. Linville (Eds), *The Archaeology of Aruba: The marine shell heritage* (pp. 9-14). The Archaeological Museum of Aruba.

Scheffers, A. (2002). Paleo tsunami evidences from boulder deposits on Aruba, Curaçao, and Bonaire. *Science of Tsunami Hazards* 20 (1), 26-37.

Scheffers, A. (2004). Tsunami imprints on the Leeward Netherlands Antilles (Aruba, Curacao, Bonaire) and their relation to other coastal problems. *Quaternary International* 120, 163-172.

Scheffler, S. (2007). Immigration and the Significance of Culture. *Philosophy and Public Affairs* 35 (2), 93-125.

Scheffers, A. R., Haviser, J., Browne, T., Scheffers, A. (2009). Tsunamis, hurricanes, the demise of coral reefs and shifts in prehistoric human populations in the Caribbean. *Quaternary International* 195, 69-87.

Sivrikaya, H. (2019). Investigations on wood destroying marine borers in the Turkish coastal waters. *Wood Industry and Engineering* 1 (1), 33-39.

Smith, H. D., Couper, A. D. (2003). The management of the underwater cultural heritage. *Journal of Cultural Heritage* 4 (1), 25-33.

Symister, C. M. A., Dijkhoff, R. A. C. F. (2022). *Spaans Lagoen and Commandeursbaai. An archaeological field evaluation on Maritime Heritage of Aruba* [Published report]. Symister Maritime Archaeological Research.

Teenstra, M. (1836). *De Nederlandsche West-Indische eilanden in derzelver tegenwoordigen toestand, Number 1, 1838.* Colonial Collection (KIT) – Leiden University Netherlands.

Thurley, S. (2005). Into the future. Our strategy for 2005-2010. *Conservation Bulletin* 49, 26-27.

Vermeij, M., Marhaver, K., Estep, A., Sandin, S. (2020). *Coral Reefs Baseline Study for Aruba 2019.* Report Carmabi Foundation Curaçao.

Versteeg, A. H., Tacoma, J. (1990). *Skeletmateriaal Aruba 1990.* Intern Rapport Archeologisch Museum Aruba 7.

Versteeg, A. H., Tacoma, J., van de Velde, P. (1990). *Archaeological investigations on Aruba: The Malmok cemetery.* Intern Rapport Archaeological Museum Aruba.

Versteeg, A. H., Ruiz, A. C. (1995). Reconstructing Brasilwood Island: the Archaeology and Landscape of Indian Aruba. *Publications of the Archaeological Museum Aruba* 6.

Veth, L. de (2012). *Burying beliefs. The Archaeological and Ethnographic study of mortuary practices of Ceramic Age groups in Colombia, Western-Venezuela and the off-shore islands.* [Published doctoral dissertation]. Leiden University.

Waldus, W. B., Overmeer, A. B. M., Verweij, J., van Campenhout, K., Dominguez, M. (2014). *Scheeprsarchaeologie in de praktijk in Nederland. Syllabus IFMAF/GIA.* Rijksuniversiteit Groningen.

Westerdahl, C. (1992). The maritime cultural landscape. *The International Journal of Nautical Archaeology* 21 (1), 5-14.

Whitton, B. A., Potts, M. (2012). Introduction to the Cyanobacteria. In B. A. Whitton (Ed), *Ecology of Cyanobacteria II. Their Diversity in Space and Time* (pp. 1-13). Springer.

Internet sources

Cambridge Dictionary. https://dictionary.cambridge.org/dictionary/english/archaeology

Directie Infrastructuur en Planning. https://www.dip.aw/ropv/. Accessed on 14-12-2023.

Culture in Development. http://www.cultureindevelopment.nl/Cultural_Heritage/What_is_Cultural_Heritage. Accessed on 13-03-2022.

Cultural Heritage. https://en.unesco.org/fieldoffice/santiago/cultura/patrimonio. Accessed on 24-04-2022.

IESA Arts and Culture. https://www.iesa.edu/paris/news-events/cultural-management-definition. Accessed on 24-04-2022.

U.S. Army Center of Military History: Chapter XVI The Caribbean in Wartime. https://history.army.mil/. Accessed on 08-12-2023.

Oorlogs Bronnen, thema: Operatie Paukenschlag. https://www.oorlogsbronnen.nl/thema/Operatie%20Paukenschlag. Accessed on 05-10-2023.

Ship Types. https://www.dhm.de/mediathek/en-ship-types/milestones-in-the-history-of-european-shipbuilding/09-fluyt/#.~:text=Late%20in%20the%20sixteenth%20century,other%20vessels%20of%20the%20time. Accessed on 08-12-2023.

Arubiana. https://arubiana.com/place/balashi-gold-mills-ruins/. Accessed on 05-10-2023.

Historia di Aruba. http://www.historiadiaruba.aw/index.php?option=com_content&task=view&id=28&Itemid=42. Accessed on 04-10-2023.

Lago Oil and Transport Co. Ltd. https://lago-colony.com/. Accessed on 06-10-2023.

AZ-Animals. https://a-z-animals.com/blog/when-is-hurricane-season-in-aruba-peak-timing-and-earliest-hurricane-on-record/#:~:text=Aruba%20gets%20a%20hurricane%20around,as%20a%20Category%201%20hurricane. Accessed on 05-10-2023.

Hurricane City. https://hurricanecity.com/city/abcislands.htm. Accessed on 19-09-2023.

Wreck of the Week. https://thewreckoftheweek.com/tag/concretion/. Accessed on 19-09-2023.

Wessex archaeology. https://www.wessexarch.co.uk/archaeological-services/watching-brief#:~:text=and%20during%20development.-,Watching%20briefs%20are%20an%20ongoing%20process%20designed%20to%20ensure%20archaeological,and%20utility%20trenching)%20is%20underway. Accessed on 19-09-2023.

Atlases and Maps

Plankaart Ruimtelijk Ontwikkelingsplankaart Aruba, 2019.

National Archief, 4.VEL[1584/1865]: NL-HaNA_4VEL_649, inv. nr. 649 - Plan van het Eyland Aruba, opgenomen met de planchet, door Engelbertus Horst, Capitain Lietenant en Ingenieur.

Internet Archive, BNA-DIG-HARTOG-CAHA-001-012-002. URL: https://archive.org/details/BNA-DIG-HARTOG-CAHA-001-012-002.

Internet Archive, BNA-DIG-KOSTBARE-0068-II. URL: https://archive.org/details/BNA-DIG-KOSTBARE-0068-II.

Appendices

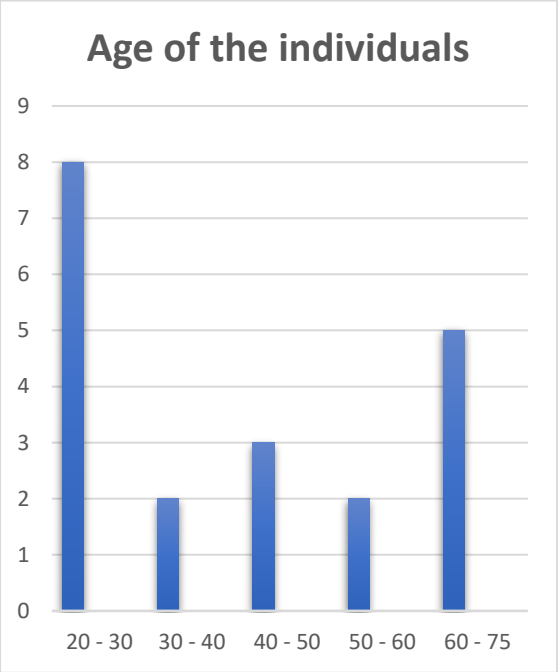
Appendix 1: Survey questions

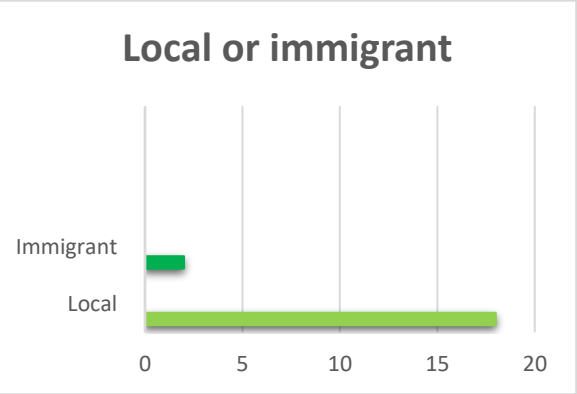
1. What is your name?
2. What is your age?
3. Were you born in Aruba?

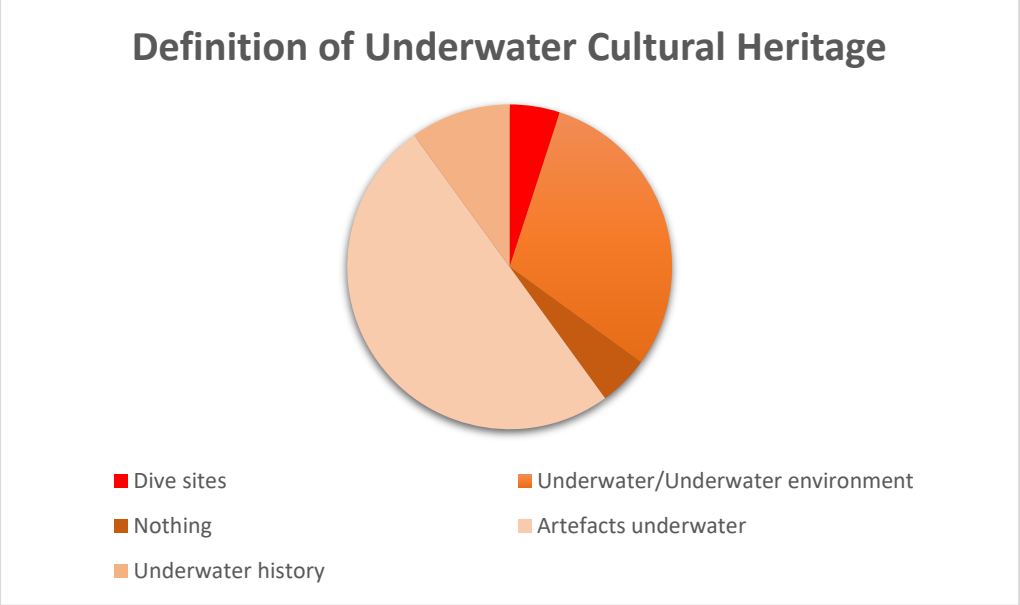
   If yes, in which region did you grow up.

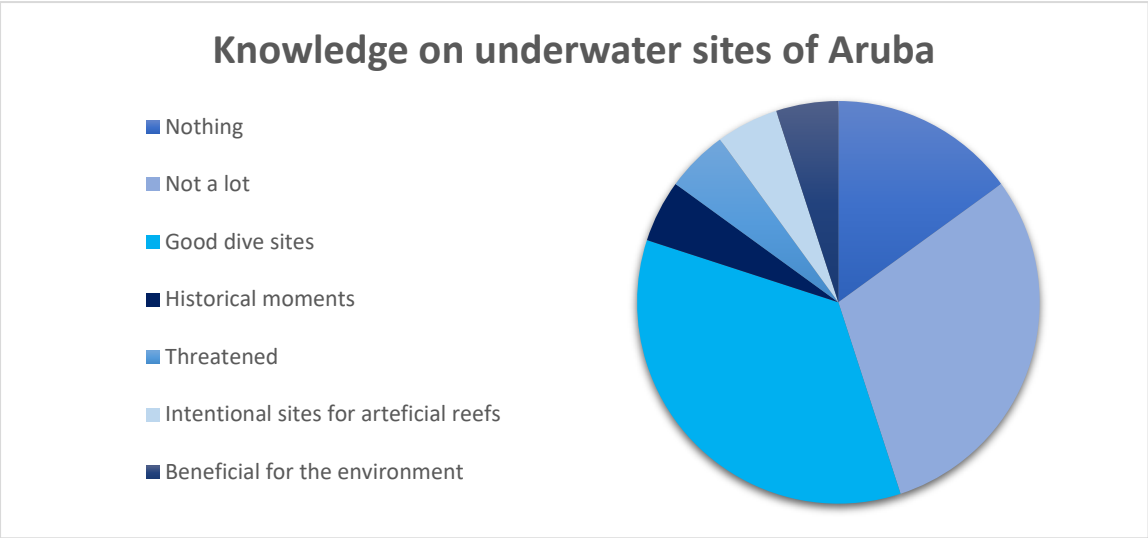
   If not, how long have you been a resident in Aruba?
4. What comes to mind when you hear the phrase “Underwater cultural heritage”?
5. What do you know about the underwater/tourist sites on Aruba?
6. Do you believe that the underwater archaeological sites form a part of Aruba’s culture and history?
7. How do you feel about the fact that these underwater sites are degrading and will one day vanish?
8. What do you think is the reason for the degradation of these underwater sites?
9. How do you think we can spread awareness, protect, manage, and preserve the underwater sites?

Appendix 2: Survey results of the local communities of Aruba







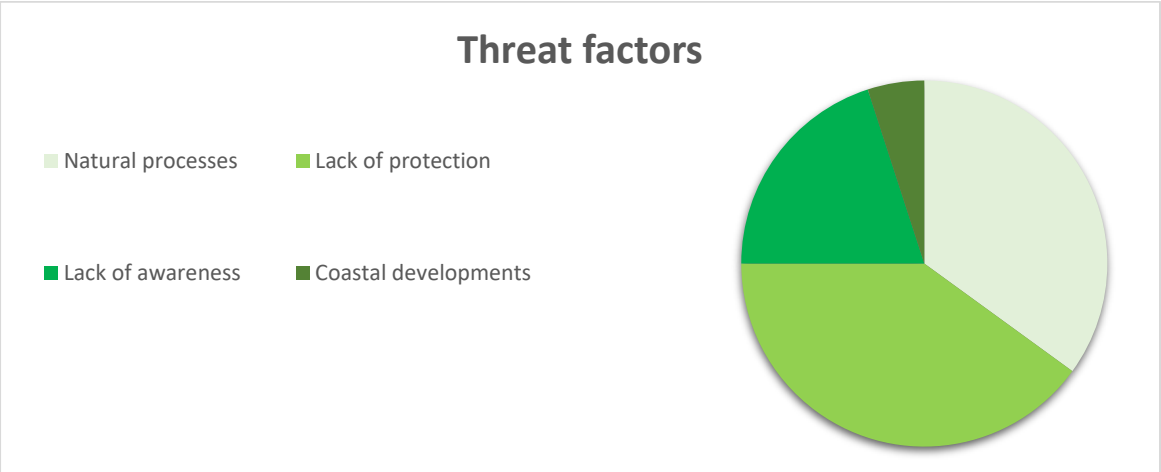


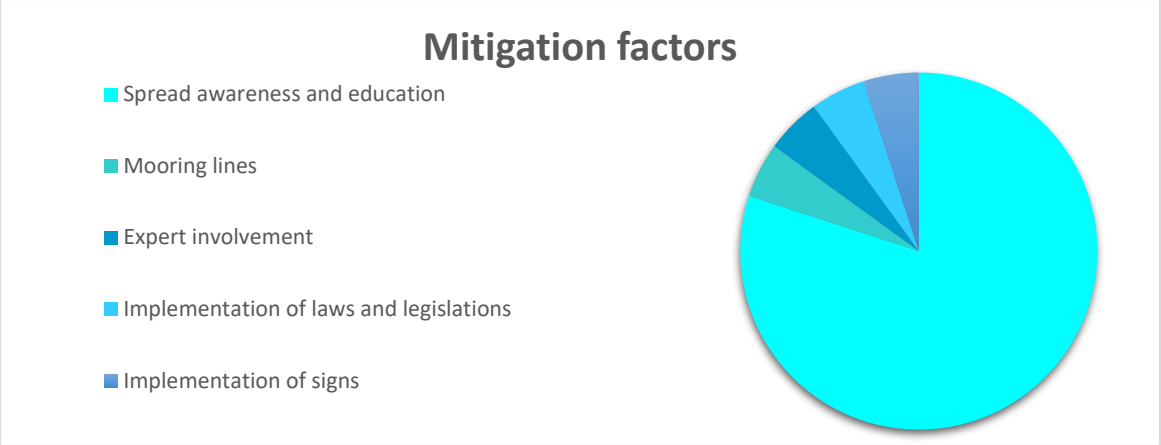
Do you believe that the underwater archaeological sites form a part of Aruba's culture and history?

Every person who was asked this question during the survey believes that the underwater archaeological sites are an important of Aruba's culture and history.

How do you feel about the fact that these underwater sites are degrading and will one day vanish?

Every individual asked regarding their feelings over the fact that the underwater archaeological sites are currently threatened, slowly deteriorating, and will one day disappear feel awful about the situation and that it needs to be mitigated against for the future of the island and the future of the tourism industry.




Mitigation factors
Spread awareness and education
Mooring lines
Expert involvement
Implementation of laws and legislations
Implementation of signs

Appendix 3: Specified archaeological expectations

Regioms	Archaeological period	Exoectations	Archaeological remains
Arashi	Archaic period 1500 BC – 900/1000 AD	Medium – High	▪ Archaic settlements ▪ Shell middens ▪ Stone and shell tools ▪ Ceramic/pottery fragments
	Ceramic period 900/1000 AD – 1515 AD	Medium – High	▪ Ceramic settlements ▪ Shell middens ▪ Stone and shell tools ▪ Ceramic/pottery fragments
	Dutch West India Company 1636 – 1791	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Cannons ▪ Anchors ▪ Ceramics and pottery fragments ▪ Bottles
	Colonial period 1792 – 1924	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
	Industrial period 1924 – 1973	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Industrial materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
Malmok	Archaic period 1500 BC – 900/1000 AD	Medium – High	▪ Archaic settlements ▪ Shell middens ▪ Stone and shell tools ▪ Ceramic/pottery fragments

Regioms	Archaeological period	Exoectations	Archaeological remains
	Ceramic period 900/1000 AD – 1515 AD	Medium – High	▪ Ceramic settlements ▪ Shell middens ▪ Stone and shell tools ▪ Ceramic/pottery fragments
	Dutch West India Company 1636 – 1791	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Cannons ▪ Anchors ▪ Ceramics and pottery fragments ▪ Bottles
	Colonial period 1792 – 1924	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
	Industrial period 1924 – 1973	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Industrial materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
Palm Beach	Archaic period 1500 BC – 900/1000 AD	Medium – High	▪ Archaic settlements ▪ Shell middens ▪ Stone and shell tools ▪ Ceramic/pottery fragments
	Ceramic period 900/1000 AD – 1515 AD	Medium – High	▪ Archaic settlements ▪ Shell middens ▪ Stone and shell tools ▪ Ceramic/pottery fragments

Regioms	Archaeological period	Exoectations	Archaeological remains
	Dutch West India Company 1636 – 1791	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Cannons ▪ Anchors ▪ Ceramics and pottery fragments ▪ Bottles
	Colonial period 1792 – 1924	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
	Industrial period 1924 – 1973	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Industrial materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
Eagle	Ceramic period 900/1000 AD – 1515 AD	Medium – High	▪ Archaic settlements ▪ Shell middens ▪ Stone and shell tools ▪ Ceramic/pottery fragments
	Dutch West India Company 1636 – 1791	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Cannons ▪ Anchors ▪ Ceramics and pottery fragments ▪ Bottles

Regioms	Archaeological period	Exoectations	Archaeological remains
	Colonial period 1792 – 1924	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
	Industrial period 1924 – 1973	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Industrial materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
Oranjestad	Ceramic period 900/1000 AD – 1515 AD	Medium – High	▪ Archaic settlements ▪ Shell middens ▪ Stone and shell tools ▪ Ceramic/pottery fragments
	Dutch West India Company 1636 – 1791	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Cannons ▪ Anchors ▪ Ceramics and pottery fragments ▪ Bottles
	Colonial period 1792 – 1924	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles

Regioms	Archaeological period	Exoectations	Archaeological remains
	Industrial period 1924 – 1973	Medium – Low	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Industrial materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
Renaissance	Dutch West India Company 1636 – 1791	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Cannons ▪ Anchors ▪ Ceramics and pottery fragments ▪ Bottles
	Industrial period 1924 – 1973	Medium – Low	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Industrial materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
Barcadera	Industrial period 1924 – 1973	Medium – Low	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Industrial materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
Spaans Lagoen	Archaic period 1500 BC – 900/1000 AD	Medium – High	▪ Archaic settlements ▪ Shell middens ▪ Stone and shell tools ▪ Ceramic/pottery fragments

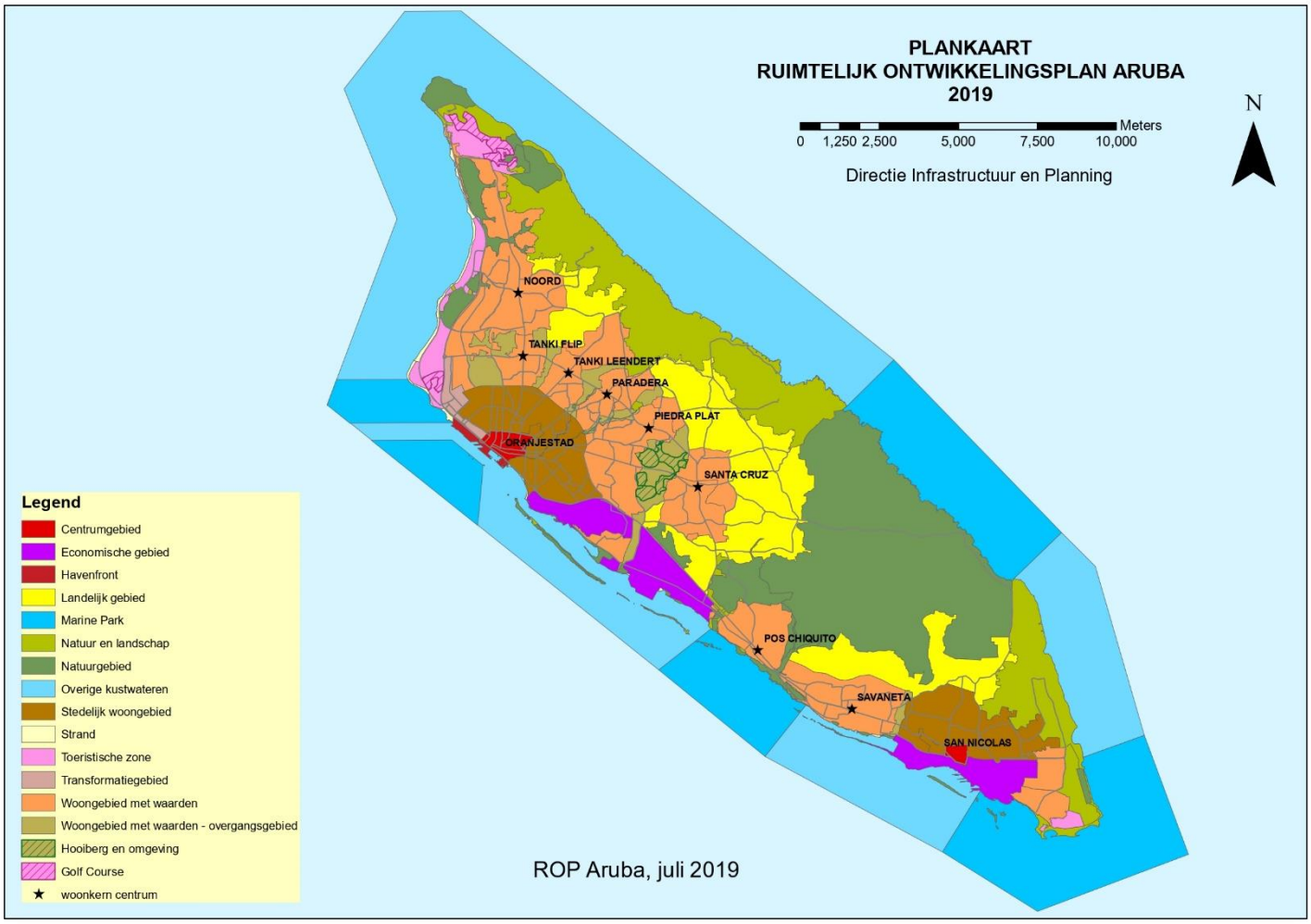
Regioms	Archaeological period	Exoectations	Archaeological remains
	Spanish period 1515 – 1636	Medium – High	▪ Ship remains ▪ Ballast stones ▪ Cannons ▪ Anchors ▪ Ceramics and pottery fragments ▪ Bottles
	Industrial period 1924 – 1973	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Industrial materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
Commandeursbaai	Ceramic period 900/1000 AD – 1515 AD	Medium – High	▪ Archaic settlements ▪ Shell middens ▪ Stone and shell tools ▪ Ceramic/pottery fragments
	Spanish period 1515 – 1636	Medium – High	▪ Ship remains ▪ Ballast stones ▪ Cannons ▪ Anchors ▪ Ceramics and pottery fragments ▪ Bottles
	Dutch West India Company 1636 – 1791	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Cannons ▪ Anchors ▪ Ceramics and pottery fragments ▪ Bottles

Regioms	Archaeological period	Exoectations	Archaeological remains
	Industrial period 1924 – 1973	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Industrial materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
San Nicolaas	Industrial period 1924 – 1973	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Industrial materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
Rodger's beach	Dutch West India Company 1636 – 1791	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Cannons ▪ Anchors ▪ Ceramics and pottery fragments ▪ Bottles
Andicuri	Colonial period 1792 – 1924	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles

Regioms	Archaeological period	Exoectations	Archaeological remains
	Industrial period 1924 – 1973	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Industrial materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
Bushiribana	Dutch West India Company 1636 – 1791	Medium – Low	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Cannons ▪ Anchors ▪ Ceramics and pottery fragments ▪ Bottles
	Colonial period 1792 – 1924	Medium – Low	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
	Industrial period 1924 – 1973	Medium – High	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Industrial materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
West punt	Colonial period 1792 – 1924	Medium – Low	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles

Regioms	Archaeological period	Exoectations	Archaeological remains
Druif beach	Colonial period 1792 – 1924	Medium – Low	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
Urirama	Colonial period 1792 – 1924	Medium – Low	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles
Daimari to Quadirikiri	Dutch West India Company 1636 – 1791	Medium – Low	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Cannons ▪ Anchors ▪ Ceramics and pottery fragments ▪ Bottles
	Colonial period 1792 – 1924	Medium – Low	▪ Shipwrecks and ship remains ▪ Personal items on board the ship ▪ Construction materials ▪ Cannons ▪ Anchors ▪ Ceramics and potter fragments ▪ Bottles

Appendix 4: Designated areas of Aruba



Designated area	**Location and status**
Center area	Paardenbaai, Oranjestad
Harbor front	Paardenbaai, Oranjestad
Economic	The regions at Renaissance, Barcadera, Balashi, De Palm Island, and San Nicolaas
Nature and Landscape area	The northern top and the regions between Daimari beach and Quadirikiri cave
Nature area	Northern tip of Aruba, the region between Quadirikiri cave and Daimari beach , renaissance island, and Mangel Halto
Sand beaches	Arashi to Eagle beach
Touristic area	Arashi to Eagle beach
Marine park	The following regions are in the process of becoming a marine park, which in turn are considered nature reserve areas and need to be protected legally under article 10 of the Nature Conservation Regulation. ▪ The region between Manchebo and Druif beach ▪ The area in front of Paardenbaai, Oranjestad ▪ The region at Pos Chiquito including Spaans Lagoen and Mangel Halto ▪ The region at San Nicolaas, including Rodger's beach, Baby beach, and Sero Colorado ▪ The region between Quadirikiri cave and Daimari beach

Appendix 5: Demographic data: SS Pedernales assemblage

Collector	Museum receival	Find nr.	Site	Region	Material	Object
Gino Wauben	Mei 2013	1	SS Pedernales	Palm Beach	Copper/iron mix	Propeller
Gino Wauben	Mei 2013	2	SS Pedernales	Palm Beach	Copper/iron mix	Metal cover
Gino Wauben	Mei 2013	3	SS Pedernales	Palm Beach	Copper/iron mix	Spoons
Gino Wauben	Mei 2013	4	SS Pedernales	Palm Beach	Copper mix	Wall hook
Gino Wauben	Mei 2013	5	SS Pedernales	Palm Beach	Copper/iron mix	Water drainage grid
Gino Wauben	Mei 2013	6	SS Pedernales	Palm Beach	Iron mix	Ship part
Gino Wauben	Mei 2013	7	SS Pedernales	Palm Beach	Copper/iron mix	Door hinge
Gino Wauben	Mei 2013	8	SS Pedernales	Palm Beach	Iron	Key
Gino Wauben	Mei 2013	9	SS Pedernales	Palm Beach	Ceramic white pottery	Egg holder
Gino Wauben	Mei 2013	10	SS Pedernales	Palm Beach	Iron, wood	Dagger
Gino Wauben	Mei 2013	11	SS Pedernales	Palm Beach	Iron, TNT, RDX	Practive bomb
Gino Wauben	Mei 2013	12	SS Pedernales	Palm Beach	Copper mix	Door handle
Gino Wauben	Mei 2013	13	SS Pedernales	Palm Beach	Copper mix	Metal tube
Gino Wauben	Mei 2013	14	SS Pedernales	Palm Beach	Copper mix	Buttons
Gino Wauben	Mei 2013	15	SS Pedernales	Palm Beach	Copper mix	Metal railing
Gino Wauben	Mei 2013	16	SS Pedernales	Palm Beach	Copper mix	Railing wall piece
Gino Wauben	Mei 2013	17	SS Pedernales	Palm Beach	Copper mix	Door hook
Gino Wauben	Mei 2013	18	SS Pedernales	Palm Beach	Copper/iron mix	Workbench clamp
Gino Wauben	Mei 2013	19	SS Pedernales	Palm Beach	Copper mix	Metal railing
Gino Wauben	Mei 2013	20	SS Pedernales	Palm Beach	Glass	Windows
Gino Wauben	Mei 2013	21	SS Pedernales	Palm Beach	Copper/iron mix	Keyhole
Gino Wauben	Mei 2013	22	SS Pedernales	Palm Beach	Copper mix	Door hook
Gino Wauben	Mei 2013	23	SS Pedernales	Palm Beach	Ceramics baked clay	Storage containers
Gino Wauben	Mei 2013	24	SS Pedernales	Palm Beach	Copper/iron mix	Door hinge
Gino Wauben	Mei 2013	25	SS Pedernales	Palm Beach	Ceramic white pottery	Cup
Gino Wauben	Mei 2013	26	SS Pedernales	Palm Beach	Wood	Binoculars
Gino Wauben	Mei 2013	27	SS Pedernales	Palm Beach	Copper mix	Microscope
Gino Wauben	Mei 2013	28	SS Pedernales	Palm Beach	Copper mix	Lamp
Gino Wauben	Mei 2013	29	SS Pedernales	Palm Beach	Copper mix	Railing wall piece
Gino Wauben	Mei 2013	30	SS Pedernales	Palm Beach	Copper mix	Small grid
Gino Wauben	Mei 2013	31	SS Pedernales	Palm Beach	Copper/iron mix	Ship part
Gino Wauben	Mei 2013	32	SS Pedernales	Palm Beach	Copper mix	Door knocker
Gino Wauben	Mei 2013	33	SS Pedernales	Palm Beach	Iron mix	Lamp

Gino Wauben	Mei 2013	34	SS Pedernales	Palm Beach	Copper/iron mix	Spinner
Gino Wauben	Mei 2013	35	SS Pedernales	Palm Beach	Copper mix	Ship part
Gino Wauben	Mei 2013	36	SS Pedernales	Palm Beach	Iron mix	Plague
Gino Wauben	Mei 2013	37	SS Pedernales	Palm Beach	Ceramic white pottery	Storage cap
Gino Wauben	Mei 2013	38	SS Pedernales	Palm Beach	Copper mix	Ship part
Gino Wauben	Mei 2013	39	SS Pedernales	Palm Beach	Copper mix	Door hook
Gino Wauben	Mei 2013	40	SS Pedernales	Palm Beach	Copper mix	Door hook
Gino Wauben	Mei 2013	41	SS Pedernales	Palm Beach	Copper/iron mix	Door hook
Gino Wauben	Mei 2013	42	SS Pedernales	Palm Beach	Copper/iron mix	Air vent
Gino Wauben	Mei 2013	43	SS Pedernales	Palm Beach	Iron	Ring
Gino Wauben	Mei 2013	44	SS Pedernales	Palm Beach	Iron and plastic	Circuit breaker
Gino Wauben	Mei 2013	45	SS Pedernales	Palm Beach	Copper/iron mix	Anchor